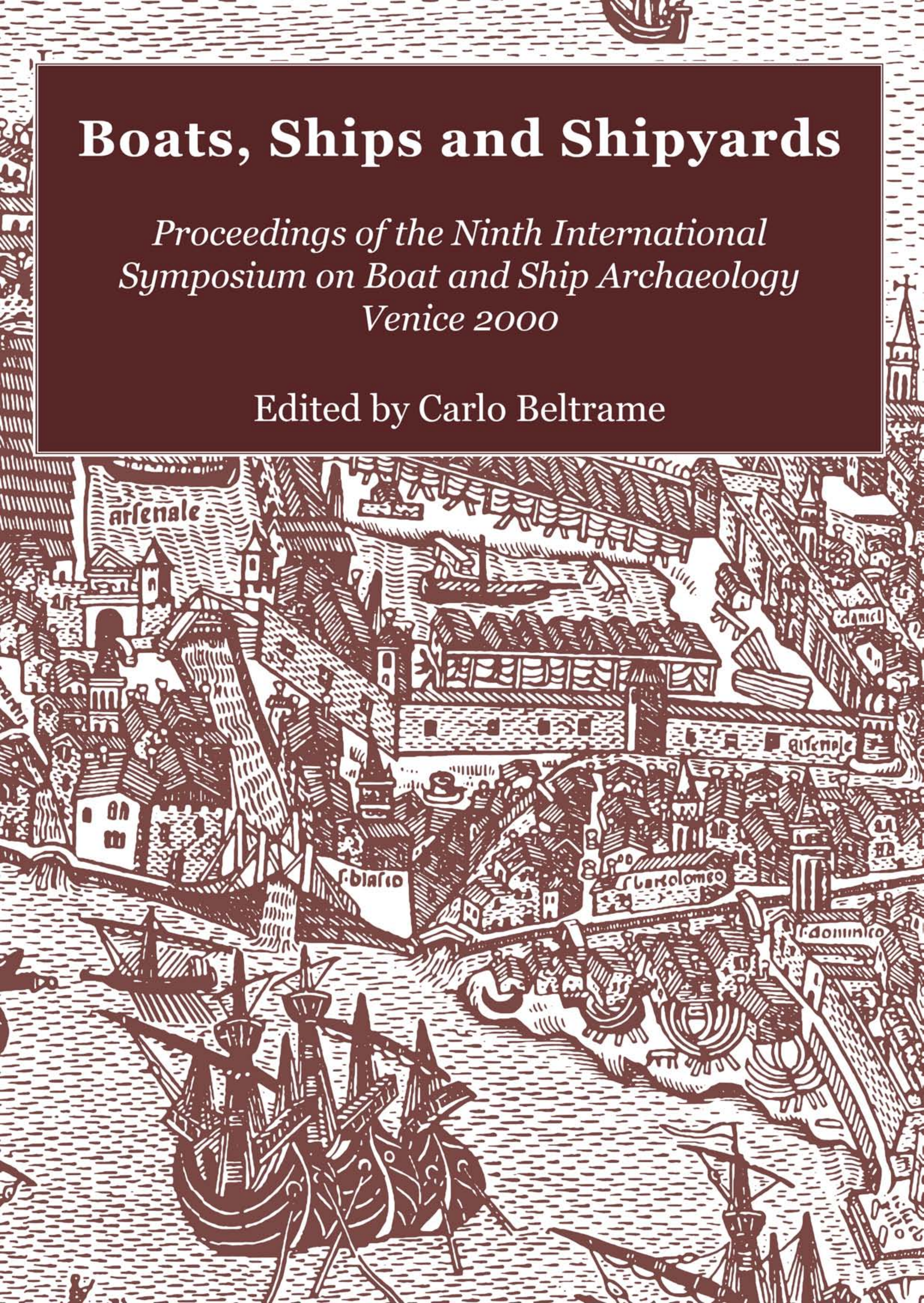
Boats, Ships and Shipyards

Proceedings of the Ninth International Symposium on Boat and Ship Archaeology

Venice 2000

Edited by Carlo Beltrame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BOATS, SHIPS AND SHIPYARDS

To Mario Marzari

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Proceedings of the Ninth International Symposium on Boat and Ship Archaeology Venice 2000

Edited by Carlo Beltrame

ISBSA 9

Università Ca' Foscari Venezia
Dipartimento di Scienze dell'Antichità e del Vicino Oriente

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Contents

List of Contributors viii

Introduction *by Carlo Beltrame* xiii

A. INTRODUCTORY PAPERS

1. Maritime Archaeology and the ISBSA – Where to in the 21st Century?
Frederick M. Hocker 1
2. Nautical Archaeology in Italy: Past, Present and Future
Carlo Beltrame 7
3. The Arsenal of Venice and the Art of Building Ships
Mauro Bondioli 10

B. MEDITERRANEAN SHIPS

4. Neolithic Watercraft in Greece: Circumstantial Evidence and Serious Guesses
Christina Marangou 14
5. Sewn Planked Boats from Early Dynastic Abydos, Egypt
Cheryl A. Ward 19
6. Towards the Determination of Mycenaean Shipbuilding Techniques, Tools and Materials
Dimitra Kamarinou 24
7. Mortise-and-Tenon Joints of Bronze Age Seagoing Ships
Cemal Pulak 28
8. Timber Supply and Ancient Naval Architecture
Frédéric Guibal, Patrice Pomey 35
9. The Late-Roman "Parco di Teodorico" Wreck, Ravenna, Italy:
Preliminary Remarks on the Hull and the Shipbuilding
Stefano Medas 42
10. *Dor D* Wreck, Tantura Lagoon, Israel
Yaacov Kahanov 49

C. RECONSTRUCTION OF SHIPS

11. Reconstruction of Marseilles 6th century BC Greek ships
Patrice Pomey 57
12. The Late-Roman *Fiumicino 1* Wreck: Reconstructing the Hull
Giulia Boetto 66
13. The Reconstruction of the *Ladby* Ship – Using a Working Spline Model and Computer
Vibeke Bischoff 71

D. THE SHIPYARDS

14. Progress in the Study of Ancient Shipsheds: a Review.
David Blackman ... 81
15. Ancient Slipways and Shipsheds on the Israeli Coast of the Mediterranean
Avner Raban ... 91
16. Operating on Shipsheds and Slipways:
Evidence of Underwater Configuration of Slipways from the *Neosoikos* of 'Trypiti'
Kalliopi Baika ... 103
17. An Early Roman Boatyard at Mainz, Germany
Olaf Höckmann ... 109
18. Essay to Restore the Operating Process of a Shipyard in the Early Medieval Period:
the Example of the *Port Berteau II* Wreck, Charente-Maritime, France
Eric Rieth ... 113
19. Nails for Shipbuilding (13th–20th centuries)
Furio Ciciliot ... 119
20. How Were Vessels Designed before the Late-Medieval Period?
Seán McGrail ... 124
21. The Hogendijk Shipyard in Zaandam and the VOC Shipyard Oostenburg in Amsterdam.
Examples of Recent Archaeological Slipway Research in the Netherlands
Jerzy Gawronski ... 132
22. Moulds, Rising Boards and Bevel Boards.
The Wooden Memory of the Shipyard of Le Locum, Lake Geneva
Paul Bloesch ... 144
23. The Tyrrell's Boatyard of Arklow, County Wicklow, Ireland
Darina Tully ... 152

E. INLAND BOATS

24. Tracing Ship Traffic without Ships – Alternative Methods of Finding Evidence
for Pre- and Early Historical Inland Water Transport
Ulrike Teigelake ... 154
25. Thoughts on the Typology of Stone Age Boat Petroglyphs
from the White Sea and Lake Onega, Russia
Maik-Jens Springmann ... 160
26. A Roman River Barge (?) Found in the Danube near Prahovo, Serbia
Ronald Bockius ... 169
27. Expanded Logboats between the Baltic and the Black Sea
Waldemar Ossowski ... 177
28. A New Look at the *Utrecht* Ship
Aleydis Van de Moortel ... 183
29. Investigation of Traditional Boatbuilding for the Reconstruction of Medieval Russian Boats
Petr Sorokin ... 190
30. Wooden Shipbuilding on Lake Constance before 1900
Dietrich Hakelberg ... 195

F. THE GALLEYS

31. The Sailing Qualities of Venetian Great Galleys in the 15th Century. Evidence of their Influence
on the Development of Sailing Ships in the Atlantic Area during the Following Century
Sergio Bellabarba ... 201
32. The Venetian Merchant Galley and the System of *Partisoni* –
Initial Steps towards Modern Ship Design
Ulrich Alertz ... 212
33. The Art of Designing and Building Venetian Galleys from the 15th to the 16th century
Mauro Bondioli ... 222

34. Reportage, Representation and Reality.
The Extent to which Chronicle Accounts and Contemporary Illustrations
can be relied upon when discussing the Tactics used in Medieval Galley Warfare
Susan Rose 228
35. Les Galères de la Vue de Venise de Jacopo de Barberi (1500)
Lucien Basch 233
36. *Kadırga*. A Technical Analysis of the Sultan's Galley
Erkut Arcak 241
37. Drachio in Context
Louis Th. Lehmann 249

G. NORTH EUROPEAN MEDIEVAL AND POST-MEDIEVAL SHIPS

38. Variations on a Theme. 11th-century Ship Types of the North
Ole Crumlin-Pedersen 253
39. The Boat *Puck – 3* in the Light of Investigation of Other Slavic Boats from 9–14th Century
Jerzy Litwin 261
40. The Szczecin Vessel – a 'Crossroad' of Shipbuilding Traditions
or a Representative Artifact of Early Medieval Boatbuilding by Western Slavs?
George Indruszewski 266
41. Large Cargo Vessels in Danish Waters 1000–1250.
Archaeological Evidence for Professional Merchant Seafaring before the Hanseatic Period
Anton Englert 273
42. Remarks on the Identification of Medieval Ship Types in Northern Europe
Timm Weski 281
43. Rare Fragments of a 13th Century Clinker Galley
found in London and Use of the Irish Wildwoods for Shipbuilding
Damian Goodburn 289
44. Clenched Lap-Strake Boat Finds from the Netherlands, between 1200 and 1600
André F.L. van Holk 296
45. Illuminating Ships: Integrating the Evidence from Images and Materials in Medieval Europe
Joe Flatman 306
46. Squares and Stripes: Remarks about Textiles Archaeology and Sails
Susan Möller-Wiering 310
47. Ships and Private Shipyards through the Archaeological Evidence of the Wreck off La Natière
(Saint-Malo, Brittany, France)
Michel L'Hour, Elisabeth Veyrat 314
48. The Mysteries of a Baltic Trader
Martijn R. Manders 320
49. Whipstaff and Helmsman. An Account of the Steering-gear of the Vasa
Olof Pipping 329

H. INTEGRATED EVIDENCE AND REPLICAS

50. Maritime Ethnography: The Reality of Analogy
Lucy Blue 334
51. A Comparison between the Earliest Testimonies of Venetian Construction Techniques
and those of the Present Day
Gilberto Penzo 339
52. Reconstruction of the *Hjortspring* Boat Sailing Tests
Knud Vagn Valbjørn, Niels Peter Fenger, Max Vinner 347
53. Two Slavonic Boat Reconstructions in the Open Air Museum Gross Raden
Trixi Gülland 357

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Introduction

The task of organising the *IX International Symposium on Boat and Ship Archaeology* was assigned, by the international scientific committee created on the occasion of the symposium at Gdansk, to the author and Giulia Boetto, backed up by the Department of Ancient Sciences and of the Near East of the University Ca' Foscari, Venice.

The scientific committee was favourable to the fact that the symposium would move from northern Europe towards the Mediterranean where no meeting had as yet been organised. In particular, the Italian choice was motivated by the interest that the whole archaeological environment had in the Italian maritime patrimony. The latter consists, not only in numerous shipwrecks of every era, especially that of antiquity, but also in maritime monuments, such as the medieval arsenals, and in the richest marine historical heritage of the whole world, represented, *in primis*, by the Renaissance manuscripts.

If the richness of the maritime culture in our country is indisputable, the queen of the Italian seas, and not only, amongst the cities of the peninsula is, without doubt, the Serenissima. Traces of the naval presence in Venetian territory have been left already since the Roman Imperial Age, but it is during the Medieval period that the city assumes the leading role; the waters of the lagoon, of recent, brought to light the only 14th century galley known and an exceptional boat with a flat bottom of the same period; in Venice nearly all note-books have been drawn up that constitute the only testimony in order to understand the naval construction of the Renaissance; Venice still conserves in its womb ancient *Arzanà*, the most formidable naval industry of history, along with small private shipyards, the *squeri*, where the constructive method of the boats has remained almost unaltered for centuries; in the city, a patrimony of traditional boats is preserved that are still used to the present day upon the waters of the lagoon, a heritage that is destined to a relentless disappearance if it is not protected in the near future and conserved so as to be handed down to posterity.

The success of a cultural initiative organised in Venice was taken for granted since the beginning. At the Auditorium Campo S. Margherita, from the 4th to the 8th of December 2000, around 190 scholars met, 65 of which presented papers whilst 22 of these exhibited posters. It was probably one of the most important gatherings that had ever occurred for marine archaeology.

The choice on behalf of the organisers of the title of the symposium does not require particular explanations: the utility of making a point of the situation in regards to knowledge on the places where the construction of ships and boats occurred, happily met with the presence of the most famous and best conserved of these environments, the *Arsenale*. And the very period in which the organisation of the symposium occurred casually coincided with the beginning of a project on behalf of the Navy, interested in re-launching the complex from a cultural point of view.

The organisation of the symposium was undertaken by the author, who acted as the general co-ordinator, and by Giulia Boetto, Sauro Gelichi and Monica Tonussi. The latter took care of many of the technical aspects. The symposium was able to count on the collaboration of many institutions (Associazione Arzanà, Associazione Italiana Archeologi Subacquei, ACTV, Circolo Artistico di Venezia, ISTIAEN, Istituzione per la Conservazione della Gondola e la Tutela del Gondoliere, Museo Storico Navale di Venezia, Soprintendenza Archeologica di Ostia, Soprintendenza Archeologica per il Veneto. The name of Ennio Concina (from the Dipartimento di Critica delle Arti "G. Mazzariol" University Ca' Foscari of Venice) must be added to these institutions, who held an inaugural lecture on the *Arsenale* as a place of production. The initiative was able to count on funds on behalf of the City of Venice and of the Region of the Veneto.

This volume, that enjoyed the precious help of the untiring Sean Mc Grail that I thank here, gathers together the papers of most of the speakers. The session represented by a larger number of presentations is obviously that on the shipyards, but space here is reserved also to other aspects of maritime archaeology that were treated in other specific sessions. The notable weight of the studies upon Mediterranean galleys must be noted, a subject particularly debated in these very last years thanks also to the discovery of the wreck of *S.Marco in Boccalama* in the southern lagoon of Venice.

The choice undertaken during the symposium to award the candidature of Roskilde in Denmark for the organisation of the ISBSA in 2003 will bring back to the North the most important worldwide gathering for maritime archaeologists. Hopefully during this occasion there will be another proposal of candidature on behalf of a Mediterranean country, for the ISBSA can, and must, be a constant presence in *Mare Nostrum*, so as to encourage research in these countries, such as Italy, that only recently are “shyly” venturing within this discipline. In regards to Italy, we hope that on the wave of enthusiasm for the recent and exceptional discoveries, it can present itself at the symposium of 2003 with a serious proposal of definite “institutionalisation” of the discipline worthy of its maritime tradition.

Carlo Beltrame

1. Maritime Archaeology and the ISBSA – Where to in the 21st Century?

Frederick M. Hocker

Introduction: the challenge facing maritime archaeology

I am a fortunate man. I entered the world in the same the week in April of 1961 that the *Vasa* was returned to the world of the living. I had the opportunity to begin my career at a point when maritime archaeology had already established a foothold in the world of academic respectability. I could attend a well-developed graduate program in nautical archaeology and gain valuable experience on a wide range of projects. I have had the good fortune to be associated with three of the leading research centers in our field, the INA/Texas A&M partnership, the Netherlands Institute for Ship and Underwater Archaeology, and now the consortium of institutions in Roskilde, and to lead projects in North America, the Mediterranean and northern Europe. And if the world will just slow down a bit, I might even publish some of them!

In reflecting on this remarkable string of luck and the even more remarkable people I have had the honor to learn from and work with, I have been struck by the situation in which maritime archaeology now finds itself as a professional discipline. Maritime archaeology in its modern sense is about the same age as I am, and as I contemplate my fortieth birthday and the midlife crisis I am obligated to have when it arrives, I am curious about how our field will handle the challenges it faces as it approaches middle age.

Some of these challenges are common to any institution or discipline as it tries to make the difficult transition from a founding generation of brilliant visionaries to a stable structure of professionals. Others are a product of the peculiarities of our field and still others part of the interesting times in which we live. I do not believe that these are problems or hurdles, as I am the official optimist of the National Museum of Denmark, but opportunities to exercise our creativity. In this brief note I would like to reflect on three particular opportunities and how the ISBSA can be developed as a force to assure the robust growth, both institutional and theoretical, of maritime archaeology. One is demographic, one is organisational, and one theoretical.

Challenge n. 1: the legacy of the Pioneers

The origins of maritime archaeology can be traced well back into the 19th century, and whether one begins with Cornelius Glavimans's excavation in Rotterdam in the 1820s or Conrad Engelhardt's work in the Nydam bog in the 1850s and '60s, there is no denying that ship archaeology, as it has often been called, has a long and well-developed history. This early work, encompassing the magnificent grave sites of Gokstad, Oseberg, and Sutton Hoo as well as the harbour excavations at Kalmar, has had a strong influence on the development of the field, particularly in Scandinavia. Still, maritime archaeology as we conceive of it today is largely a child of the 1950s and 1960s. In these years, the new accessibility to the underwater world provided by scuba combined with the post-war development projects to reveal an extraordinary number of sites to professionals and amateurs alike. In the years around 1960, a series of grand projects focused engineering and archaeological resources on shipwrecks that have since come to dominate the "canon" of sites commonly used to sketch the history of seafaring. *Vasa* in Sweden, the Bremen cog in Germany, the Skuldelev Viking ships in Denmark, the Bronze Age wreck at Cape Gelidonya in Turkey and the Pharaonic barge from the Pyramid of Khufu in Egypt were all excavated in the same short period. A second wave of major excavations captured the public imagination in the late 1960s and 1970s, from the little Kyrenia ship near Cyprus to the titanic Madrague de Giens ship in France to the East Indiaman *Batavia* in Australia, to what might be considered the last of these monumental projects, the *Mary Rose* in England. Many of these projects had an iconic quality to them, providing a tangible reminder and potent symbol of the past glory of the countries in which they were excavated.

These grand excavations threw up a generation of archaeologists who were able to use the public fascination with these wonders from the deep to establish institutions and research programs to further develop the field, and they threw themselves into new excavations and the spreading of the new gospel with energy and creativity. George Bass, Ole Crumlin, Carl Olof Cederlund, Detlev Elmers, Patrice Pomey, Jeremy Green are known today not because they participated in or led large-scale projects twenty-five to forty years ago, but because they had the vision to look beyond those projects and see the shape of a discipline that could be built around them. Before these excavations began, a small group of what might be called responsible wreck divers brought the archaeological potential of the sea bottom to public attention. We must number among them Frederic Dumas, Peter Throckmorton, Honor Frost, and, in a sense, Ted Wright. A second group of scholars, epitomized by Arne Emil Christensen, Béat Arnold and Richard Steffy, have concentrated on getting the details right, on establishing a strong set of scholarly standards that would meet the demanding criteria of a skeptical academic establishment. A third group, represented in brief by Lucien Basch, Lionel Casson, and Olof Hasslof, themselves not excavators, began the work of integrating the new knowledge from underwater excavations into the broader framework of a maritime past. There are the synthesists, such as Basil Greenhill, those who attempted to give shape to the growing body of theory and data concerning that maritime past, partly through their own writings and partly through the organizing of conferences and symposia. In this group, Séan McGrail stands out not only for his own taxonomic work, but also for the series of thematic conferences he held in the 1970s, most particularly the first ISBSA.

Finally, no summary of the origins of our field would be complete without mentioning such larger-than-life figures as Mendel Petersen, Robert Marx, and Teddy Tucker. While it is now fashionable to disparage them as looters or scoundrels, they were motivated as much by a love of history as by a love of gold. In earlier days, when the line between archaeologist and treasure hunter was not so sharply drawn, their roguish charm and dash encouraged the public enthusiasm for investigating sunken ships and drowned cities. I will confess, if no one else will, that I read Marx's *Diving for Sunken Treasure* before Bass's *Archaeology Under Water*. There are many more as well whom we all think of as our elder statesmen, the Elisha Linders and the Gerhard Käpitäns, the David Blackmans and Colin Martins, who have established the educational programs essential to the professionalization of the discipline and explored aspects of the maritime past that were essential but not necessarily as glamorous as the big shipwreck projects.

These people created something from nothing, and the magnitude of that accomplishment and the debt we owe them is now difficult for most of us to comprehend. Those of us in our twenties, thirties and forties are, in a famous medieval phrase, as dwarves peeking over the shoulders of giants. We also bear the burden of carrying on. As our teachers and mentors reach retirement, we are faced with a particularly difficult challenge – to live up to the standards they have established and transform the structures they created into professional institutions with long and secure futures.

Will we be Louis the Pious to their CharleMagne, or Hadrian to their Trajan? The pioneers laboured under a unique set of circumstances, in an environment as free of expectations as it was of infrastructural support. As with all great creators and builders in history, they hand on to their successors a particularly thorny challenge. The work of consolidating the gains of the past and maintaining a high level of enthusiasm in a public now used to dramatic discoveries is less glamorous, perhaps less exhilarating than building something from scratch, although it is also perhaps less strenuous. History rarely remembers the successors to great leaders except for their failures, their inability to hold together the disparate forces gathered by their more charismatic or ruthless predecessors.

Institutions, on the other hand, have a somewhat better track record in this regard than emperors. The very nature of an institution is predicated on the need to establish a structure capable of prospering under good leadership and surviving under bad. The test of an organization's inherent strength comes in the transition from a small group based on personal relationships to a larger group based on professional relationships, a transition usually associated with the retirement of the founders. When organizations fail this test, it is often because the structure depends too much on the personal qualities of the founders or because the second generation is ill-prepared for the demands of leadership. Will the institutions of the Heroic Age survive under new leaders, or will they be replaced by new institutions? Probably a mixture of both, if history is any guide.

There is no lack of talented archaeologists in what we might call the second generation. Texas A&M, East Carolina University, St. Andrews, Haifa have been turning out well-prepared professionals for over two decades. The list is so long that to mention any by name would be unfair to the rest. But to assure maritime archaeology of a future as vital and absorbing as its past, we need not only skilled excavators and thorough scholars, but leaders and visionaries. Where are the leaders of the next generation and what are their ideas for where we should be going?

We should not forget what we might call the "first and a half" generation, people in their late forties and fifties. In some ways, some of them are a lost generation, people who began their careers as assistants to the pioneers and never completely moved out from under their shadow. But there are others, visionaries and builders in their own right, who can offer a good sense of direction and are already working on assuring a future for the field in their own regions. There is a whole generation of archaeologists in

Israel, such as Avner Raban, Michal Artzy and Sarah Arenson, who have extended the boundaries of what is considered maritime archaeology. There are theorists, such as Christer Westerdahl, who have tried to build the link between Man, the sea and the landscape. There are builders, such as Jerzy Litwin in Poland and Robert Grenier in Canada, who have painstakingly created strong institutions. The great unfulfilled promise in this group is of course the late Keith Muckelroy, whose ideas continue to influence how we think about maritime sites. I will take the risk of naming here two men who have carried on in his tradition. Jon Adams has been instrumental in building an outstanding academic program in Southampton, England, one that attracts students from around the world. Now if someone could just get him a 34-hour day. Even though I disagree with about a third of everything he says, I still think Thijs Maarleveld is one of the most creative theoretical thinkers active in our field today. His ideas are laying the foundation for a rational theoretical framework for maritime archaeology. These are the sort of people I would follow.

This does not mean that it is time to pension off our heroes and wish them a happy retirement. I do not advocate a revolt of the young. On the contrary, it is important to us that our mentors stay active in our field as long as possible. They are the embodied wisdom of the formative years of this discipline and still have much to teach us. I would personally appreciate it if Ole Crumlin would not retire until I am ready to put down my scuba gear in about 2030. He will only be 95 then... Each of us has our own heroes – it is a natural human tendency. In the next week, make sure you tell them how much they mean to you.

Challenge n. 2: preserving a research capability

For the most part, the monumental projects of the period up to about 1980 gave way to much smaller efforts in the succeeding decades, as research staffs struggled with the problems of analyzing, interpreting, and publishing such large, complex finds and as the enthusiasm for such outlandish commitments of resources dimmed among the governments and foundations and agencies that funded maritime archaeological research. You might say we are the cultural equivalent of the Space Program. At the same time, the growth of maritime archaeology as a professional discipline has been matched by growth in public awareness of the value and fragility of material past, with a positive impact on the way people regard the exploitation of historic resources for commercial gain. It would be foolish to say that we are "winning the war against treasure hunting," but clear progress has been made in the last twenty years. More and more countries have expanded their cultural heritage protection laws to include the sea bottom, or developed new laws and guidelines to protect historic shipwrecks. This has included some stunning reversals for commercial firms, such as the Portuguese repeal of laws favorable to treasure salvors and the establishment of a national authority to monitor and manage the submerged cultural heritage.

The clearest sign that public opinion in many countries has shifted in favor of responsible archaeology over pure commercialism is the number of salvage companies that now employ archaeologists. Even if these "tame" or "token" professionals are only window dressing, they are an acknowledgement by commercial interests that irresponsible destruction of the past does not play well with investors. From a purely economic perspective, one might say that the salvors have discovered that provenance increases a looted object's value and have acted to maximize profits. A few have even gone so far as to challenge the ability of professional archaeologists to do better field work. The "greed is good" values of the 1980s have given way to a more responsible viewpoint in the management of non-renewable resources like historic sites. I do not wish to engage in the archaeology vs. treasure hunting debate here – as the American archaeologist Billy Ray Morris once said, "I've seen this movie, and everyone dies at the end" – but I would like to point out that we should not fool ourselves into thinking that this change in public attitudes is a permanent shift in consciousness. We are merely heading for the opposite extreme of a repetitive cycle, and should make the most of it while we can. We should also learn a lesson from the generally superior marketing skills of the successful salvors. Those of us playing Jeremiah and hectoring the public from a morally superior position have had less positive influence than those who have been able to communicate the greater excitement and public benefits of good archaeology.

One consequence of the growth in public awareness of the importance of a common submerged or buried maritime heritage is an increase in the demand for professional archaeologists to care for these resources. The creation of state agencies charged with managing submerged cultural resources has given work to a large number of archaeologists. Preservation codes requiring surveys or excavations of sites threatened by development have stimulated the growth both of state offices and commercial firms providing this archaeological work as a mandated or contracted service. The largest of the private concerns, American firms that provide multi-faceted environmental and cultural resource impact evaluations, create a steady demand for field staff with basic skills. This demand is strong enough to influence the curricula of university programs teaching maritime archaeology.

One result of this growth in employment is that more of us are primarily employed to preserve and manage the past than to study it. Public funding for archaeology in many places is largely if not entirely directed to rescue and monitoring work, and the pace at which most rescue and mitigation work has to be done leaves neither time nor resources for any kind of broad or deep analysis of the material. Research, the unfettered, creative investigation of the maritime past, is increasingly a hobby pursuit for full-time professionals trying to salvage a small piece of the past from the onrushing bulldozers and dredges. In places where funding is truly minimal, a sort of siege mentality has set in, where pure research archaeology is effectively condemned by some as wasteful and destructive. We should only dig where we must and leave the other sites for future generations, with superior techniques. At the risk of offending some in this room, I must ask, how on earth did we come to this?

Research, not simply documentation and preservation, is the cornerstone of our field. The desire to know and understand the past drives us as much as the excitement of finding old things in the mud. It is what separates us from looters and it is what fuels the public fascination with archaeology. I do not just want to save the past, but to grasp it, comprehend it, use it to inform the choices I make for the future. I believe that it is not just the low pay, high workload and difficult conditions that cause such a high burn-out rate in contract archaeologists, but the frustration of watching so much of the past fly by without the chance to come to terms with it. Without a strategy for preservation constantly refreshed by new data and challenged by new questions, we are in danger of saving the wrong things.

A few bastions of research-oriented archaeology are still plugging away, willing to take on big questions and big projects. First among these must be the Institute of Nautical Archaeology at Texas A&M. Perhaps better than any other institution, it has kept alive the passion that drove the projects of the sixties. Through the 70s and 80s and into the 90s, as many other institutions were being closed or focusing on more and more limited projects, INA continued to excavate major sites to completion, culminating in the 11-year effort at depths over 45 m on the Bronze Age shipwreck at Uluburun. INA may be criticized with justification for a certain old-fashionedness and resistance to new ideas, but its commitment to the ideals that got most of us into this field has never wavered. The urge to understand as well as preserve, to analyze as well as record, is alive and well in College Station.

The relatively recent creation of the Centre for Maritime Archaeology in Roskilde is a sign that funding is still available for pure research. As a new employee there, I can only tell you that everything you suspected or have heard is true. We are scholars turned loose to answer the questions that intrigue us. We are not entirely free – Ole Crumlin's watchful eye makes sure that each of our projects contributes to an integrated research strategy, and there is not really a money tree in the back garden – but it is an amazing opportunity that I wish every one of you could have.

These oases are the exception, and as the toughest plants thrive in the stoniest soil, the most creative research programs are being carried out in some of the most management driven environments. The work of Peter Marsden, Gustav Milne and Damian Goodburn at the Museum of London is a shining example of using threatened sites and small projects to construct, piece by piece, a comprehensive picture of the maritime past. The commitment of NISA to keeping a research avenue open is also admirable. This institution has taken a unique approach to research in a high-pressure rescue archaeology environment. How many of us would willingly open our archives to outside researchers to study? Yet that is precisely what NISA has done for fifteen years, invited students in to take on a site and bring it to publication, or even to direct excavations.

I believe it is imperative for the health of our field, both in terms of the mental health of archaeologists and of the healthy management of the maritime cultural heritage, that we do what is necessary to preserve a strong research capability. I do not mean to decry preservation and management, or to sacrifice sites purely for the fun of a big excavation. Preservation and understanding must go hand in hand, both to allow us to preserve wisely and to maintain public interest and confidence in our wisdom.

Challenge n. 3: The need for an integrated, global perspective

If we are to preserve a strong research sector, what should the subject of that research be? I have watched this debate rage in archaeology for the last two decades, the New Archaeology, the processual/post-processual divide, etc. Within maritime archaeology, a field sometimes accused of being devoid of theoretical underpinnings, there has also been some very specialised discussion of particular aspects of interpreting maritime material, much of it dealing with the problems of classification and typology for sites (Muckelroy and Cederlund's) and ships (McGrail and Maarleveld). There has also been the continuing debate over what we should call the field, ship archaeology, maritime archaeology, nautical archaeology, even the recent suggestion hydroarchaeology. I am still struggling to toe the party line at my new place of employment, where it is *marinarkæologi* in Danish but maritime archaeology in English, after fifteen years in Texas calling it nautical archaeology. I am at this point too confused to have an opinion.

I do not believe that there is a single, correct research methodology. The famous statement "archaeology is anthropology or it is nothing" is ludicrous. We all have different questions and different sorts of questions that we want answered. There is no reason that different viewpoints cannot co-exist, historical particularism alongside post-processualism. In the long run, the more important consideration is whether the work is of good quality or not. Excavations carried out a century ago and the publications derived from them are not valuable today because of the theoretical framework within which they were produced but because they were based on sound field work, good documentation and clear presentation. They give us the opportunity today to apply whatever theoretical approach suits us. On the other hand, publications that sacrifice these practical considerations to theoretical purity may not stand the test of time so well. As any historical reading in the theoretical debate will indicate, it is as heavily influenced by fashion as it is by reason. Cultural materialism is as clearly a product of the neo-marxist leanings of post-war humanities academics as it is a brilliant distillation of the relationship between environment and culture. Or, as more than one ship archaeologist has remarked in recent years, the study of ideological and cognitive questions is currently accorded somewhat more prestige than the investigation of more practical issues, which is seen as "old-fashioned."

With this caveat in mind, it is still vital to remember that good archaeology depends on the ability to ask useful (and answerable) questions of the material. Frequent discussion of those questions is an essential tool in the constant renewal necessary for the health of the discipline. In that spirit, and perfectly aware that my point of view is a product of my personal experience and interests, I would like to suggest that there is an entire area of very big questions staring us in the face. These concern the broader geographical relationships in the maritime world, as well as what one might term the political geography of our field.

With some exceptions, the archaeology of a particular country tends to be dominated by that country's citizens with some spillover into neighboring countries. This is partly a practical matter, the result of the national nature of funding and permitting for projects. It is also a matter of ethnicity, cultural identity, and a natural interest in one's own past. Where research interests have been more broadly spread, it is sometimes seen as the remnant of a colonial past, with the developed countries of the West sending digs to exploit the treasures of the Middle East, etc. In the case of the numerous American overseas projects, it is sometimes claimed that we have so little past and culture of our own that we have no choice but to poach on others' ground.

Whatever the cause, one result is that maritime archaeology has tended to be rather tightly focused in a geographical sense. There are thus quite well developed maritime histories and archaeologies of particular countries or bodies of water, but the literature on the relationships between different regions is relatively thin outside the study of exploration and colonial empires. Accompanying this trend is the problem of the very uneven distribution of work, with extensive research or management programs in some places and little or no systematic work in others. Thus, despite suspected or even well known links between particular regions, the picture we have is only a partial one. We know quite a bit about Vikings and their ships, but relatively little about Arab seafarers in the same period, yet Arab culture of the same time spread over much of the globe and maintained many of the seafaring links that knitted the long-distance trade in luxuries together. The VOC did not just build huge *retourschepen* for the long voyages to the East Indies, but also managed an overseas transport network made up of all sorts of local craft. What we lack as a field is a well-formulated global perspective on seafaring. This is in some ways paradoxical, as the whole purpose of building boats is to extend one's horizons, either personal, economic or political.

There have been some notable attempts to bridge the gaps between well-studied regions. Basil Greenhill and Seán McGrail have both done extensive work in trying to formulate general theories on the evolution of boats based on the comparison of watercraft from all over the globe. McGrail has a new book addressing just this subject appearing later this year, suggesting that he is not yet taking the idea of retirement too seriously. Outside of Europe or the finds of European watercraft, they have had to rely largely on ethnographic and iconographic evidence, as the number of well excavated and published shipfinds from outside of Europe, North America and Australia is very small. The Western Australia Maritime Museum has done some outstanding work in trying to document traditional boatbuilding around the Indian Ocean, as have individuals such as Erik Petersen, following in the footsteps of Hornell. Western Australia has also engaged or assisted in several excavations of non-western ships in the same region.

These efforts are a good start, as are recent cooperative efforts, often under EU sponsorship, between research centers in Europe. Further progress will depend on more such cooperative research, and on encouraging the development of maritime archaeology in the rest of the world. The established centers are best placed to do this, even though they all have their hands full.

I am not suggesting that we engage in trendy 1990s multiculturalism just because it is the currently fashionable political choice, or that we should pour our resources into the developing countries in order to assuage our guilt over a colonial past, although those motivations might well liberate some funding for the cause. I am insisting that we broaden our horizons because it is fully in the tradition of maritime enterprise and it will produce a better understanding of the maritime past.

The role of ISBSA?

This meeting was originally conceived as an opportunity to focus on the specific problems of interpreting the remains of ships and investigating the process of shipbuilding, and over nearly 25 years has stuck fairly closely to that ideal. This has been fine with me, I am at heart just a failed boatbuilder, as my colleague Vibeke Bischof once called me. But in those 25 years, our field has broadened considerably to address a wide range of aspects of the maritime past, some seemingly quite far removed from boats and boatbuilding. Submerged coastal settlements, the diet of maritime communities, social organization of coastal societies, and the topography of maritime towns are all relevant to our understanding of the relationship between Man and the Sea, and are all currently the subject of fairly major research projects. More importantly for us at this meeting, they are part of the same picture in which boats and ships figure so prominently and have direct or indirect influences on how people build and use watercraft.

There are also now a great many more projects under way, especially if one includes the management-driven excavations and those projects not dealing directly with ships but other aspects of maritime culture. There needs to be a forum for the presentation of new results on a regular basis, such as the annual meeting of the SHA in America. One conference every three years is not big enough to hold all of this new knowledge, yet an annual conference devoted solely to ship finds would have trouble filling the program. There may well be a need for an annual European conference on maritime archaeology in its broadest sense, as a way of keeping everyone up to date and maintaining a lively debate on a wide range of research and management issues. Such a meeting could include a large number of contributions, perhaps in parallel sessions, with an emphasis on recent work and project updates. I cannot really take any credit for this idea, and I thank Jan Bill for allowing me to steal it from him.

This would then free the ISBSA to do what it has always done best, to concentrate scholarly efforts on a particular problem or group of problems of international relevance. The current three-year schedule would provide sufficient time for the formulation of good questions and the accumulation and analysis of data for well-considered answers. The creation of an annual meeting for project reports would also free the organisers of ISBSA of the always difficult necessity of finding a way to shoehorn in a large number of project updates.

Should this proposal be considered, I offer some suggestions to the organisers of future ISBSAs:

First, I would ask the organisers of future meetings to actively encourage the participation of as wide an audience as possible. This breadth should be both chronological, bringing in students as well as veterans, and geographical, facilitating participation from as many regions and countries as possible. This means working very hard at keeping conference costs down for those less able to afford the travel and accommodation, or seeking supplementary funding to sponsor participation. This also means choosing themes and papers that are relevant to a broad audience.

Second, I would encourage the organising committees of future conferences to include younger scholars in the process. Their perspective can be of great use. In this regard it is reassuring to note that the primary organisers of the 9th meeting, Carlo Beltrame and Giulia Boetto are both younger than I am. Babes in the woods perhaps, but ably assisted by Ole Crumlin, Patrice Pomey, Jerzy Litwin, and Séan McGrail.

Third, I would plead with future organisers to keep the focus of the ISBSA firmly on research. There are plenty of other fora for the presentation of management projects. By keeping a prestigious conference concentrated on well-considered analysis, they will not only help to keep healthy debate alive and benefit our understanding of the past, but they will also provide an incentive to management-preoccupied colleagues to reserve a little time and effort for pure research.

Fourth, I would ask organisers to remember that the success of a conference of this nature is not judged by the number of papers presented, but by the quality of the presentations and the depth of the discourse. This is not just an opportunity to put another notch in the CV, no matter how attractive that may be to those whose salaries are calculated directly on such things. There must be time available for discussion, both formal and informal, in an atmosphere of respect.

Finally, I challenge all of us to think of our responsibility to the future, our obligation to the people who have brought us this far. They did not create this discipline so that we could simply absorb wisdom from on high or have fun jobs. Their accomplishment demands the best that we have to give, in the field and in the meeting hall. The future of this field does not depend on fancy buildings or sophisticated institutional structures, but on people with vision and a passion for understanding the maritime past.

2. Nautical Archaeology in Italy: Past, Present and Future

Carlo Beltrame

> "I think it is my duty to inform Your Lordship that in doing the excavations for a reclaimed canal in the town of Contarina, there have been found some signs of nautical constructions which seem to be well preserved. Just now it is possible to see the head frames of a ship which can be about six meters wide and thirty meters long. Near them there are also some other remains whose identity cannot be precisely defined, but there is no doubt that they have nautical features."

This is the message that an Italian naval officer sent to an admiral, on the 2nd January 1898, to notify him of the discovery of two shipwrecks in Contarina, a town on the Adriatic coast. This was the beginning of nautical archaeology in Italy seen in scientific terms.

After this discovery the officers got in touch with the Reale Deputazione which at that time supervised antiquities. A committee of experts realised the historical importance of this discovery, the ships were in fact from the 14th and the 16th century, and they took great care to preserve immediately the site of the discovery. Excavation began only one month later and, in few weeks, the ships were excavated, documented and recovered (Occioni-Bonaffons, 1901).

Besides the extraordinary opportuneness of the work, it is important to point out the extreme scientific strictness of their methods. The excavation of the ships was accurately documented by means of drawings and photos; then they were dismantled, packed up, and brought to the *Arsenale* in Venice. Models in 1:10 scale, which are now on display at the Naval Museum in Venice, were built. The whole project was fully described in a written report where one can also read reflections upon the environment of deposition.[1]

In 1928, a project began to recover the Nemi ships, involving lowering the level of the water in the lake. This was a Pharaonic endeavour, involving extensive engineering: a machine scooped the water and pumped it through an ancient outlet. The engineers succeeded in lowering the level of the lake by 22 m. The two famous ships of Caligula were towed to the shore where a museum was built for their display, but unfortunately they were destroyed when the museum burned in 1944. The loss of ships such as those of Contarina has been offset thanks to the execution of scale models. It is interesting to note that models today have an important role in the methodology of research in nautical archaeology.

The entire project for the recovery of the ships was fully documented and published in a lengthy volume richly illustrated with photos and drawings of the hulls (Ucelli, 1950).

After these two early undertaking, several years passed before another wreck was worked on in Italy. In fact, this happened in 1965 when the remains of a Byzantine ship were recovered during dredging at Pantano Longarini, near Siracuse (Throckmorton, Throckmorton, 1973) and also when the Natural History Museum in Verona promoted the exploratory work on a Venetian *fusta* in Lake Garda (Scandurra, 1972).

More than a century has passed since the ship excavation in Contarina, but Italy, probably only in these last months and thanks to a lot of extraordinary discoveries, now understands the real importance of nautical archaeology.

At the beginning, our country was moving in the right direction, with excavations in Contarina and in Nemi, and it considered nautical archaeology as important as other scientific disciplines. It was more far-sighted than most countries in the world, applying methods and techniques taken from other ancient sectors. Unfortunately it is not so nowadays and Italy has accumulated delay in comparison with the international context.

Nautical archaeology is particularly lively in several countries as for example in Holland, where a new research centre has been opened (see also Hocker, 2003). This liveliness is evident in the great number of proposals to organise the next two conferences of the ISBSA.

In Italy, the situation is quickly changing for the better only very recently, and probably the organization of the last ISBSA in Venice has stimulated an interest, especially at academic level. The wish, that we made during the symposium, that the enthusiastic support, offered to this event by Ca' Foscari University, could stimulate this and others academic institutions to promote such studies has produced positive effects. Very recently, a course in Maritime Archaeology has been introduced to an Italian university (Venice) and new courses, perhaps in Nautical Archaeology, will be opened in the near future elsewhere.

Perhaps we should be optimistic when we consider the recent activities, in this field, of the Ministero dei Beni e delle Attivita' Culturali.

It must be said that this office does not have any expert in ship construction among its members. Few museums have ships' remains and the only real nautical museums are that of the Roman ships in Fiumicino and that in Venice (related to the Defence Ministry). But soon, in Grado, a museum will open dedicated to the Roman ship, found off its beaches. Its hull will be assembled only after accurate conservation; in the meantime, the cargo and the fittings onboard the ship will be shown to the public. Furthermore, the building of a museum of nautical and ethnographical archaeology is a future project either for the Ministery of Defence or of Beni e Attività Culturali. The idea is to build a museum dedicated to the maritime history of the Serenissima and to the nautical tradition of Italy.

Despite the past lack of interest by institutions, the water and the wet sites of our country have brought back ships belonging to several historical periods.

Not far off Gela, lies the wreck of a ship built with planks connected to each other by ligatures, dating to the Archaic era (Freschi, 1991). The study of this evidence will be of great interest for comparison with the Greek Age sewn hull recovered in Marseille by P. Pomey. Near the Gela wreck, another Greek hull was recently discovered.

At Torre Santa Sabina near Brindisi, a hull with a rare example of a foremast from the Classical era awaits investigation only about 10 m from shore (Beltrame, 1996). In 1999, a Roman wreck, partially sewn, was excavated in the River Stella, near Udine (panel at the Symposium), while another, built with mortise-and-tenons, has been investigated at Santa Marinella. In Alghero bay, four ships with their cargo from the 16th to the 17th centuries are preserved in very good condition near the beach.

Finally, we want to remind you of the several wrecks found in the Roman harbour in Pisa: these ships are very well preserved and have very peculiar features (Bruni, ed., 1999). Amongst these wrecks are a long and narrow river boat and a boat with rowing benches, which are well preserved as is the hull; two big cargo ships, one of them still with its amphores; a probable early-medieval ship, upside down, which preserves all the upper works and the deck; and other wrecks in not such a good condition. All of them are unique pieces which, if properly documented and studied, will let us write new chapters in the history of ancient naval technology. Moreover, we want to remind you of a 5th century AD small ship found in Ravenna, which could make an important contribution to the understanding of the evolution from ships assembled by mortise and tenons and vessels where planks are only nailed to the frames (Maioli, Medas, 2001); then I want to mention also the 14th century galley and flat bottom boat recovered in Venice and of the discovery of eight or so wrecks dating between late antiquity and the Middle Ages covered with sand in Olbia (Riccardi, Naxos 2001). I do not want to forget also several Roman shipwrecks, including that one recovered far off Grado.

Unfortunately, most of these discoveries are not always treated according to scientifically and methodologically correct rules. Often haste influences working choices and improvisation, too often, prevails.

Among several examples that we could mention, the most evident is that of Pisa where, without listening to criticism, they have worked without the advice of a nautical archaeologist. It is not a coincidence that the ships of Pisa have not been presented by anyone at the Venice symposium.

In the past, there have also been projects undertaken using proper methods; one of the earliest was led by foreigner researchers. I am speaking about the excavation, the recovery and the exhibition in a museum of the Punic ship; this work should be an example for Italian archaeologists (Frost, 1976).

More recently, Italian archaeologists have also carried out more rigorous projects. The most recent is the excavation and recovery of the, already mentioned, wreck of the Teodorico's Mausoleum, where a specialist was present (althought not as director of the operations...). Another example is the work of the Superintendency of Ostia in the promotion of the study of the Roman ships displayed in the Fiumicino museum and in the project to exploit the complex (see also Boetto, 2003). Finally, the Superintendency of Friuli Venezia-Giulia and the newborne NAUSICAA centre of Venice recently decided, after mistakes made in the past, to "turn over the page" in the managerial politics concerning the reseach project of the Roman wreck of Grado. A project for the documentation, the study and the theoretical reconstruction of this ship is in progress. After conservation (in progress too), the hull will be re-assembled in the museum (Beltrame, Gaddi, 2000).

Looking at the research studies and at the literature, but also at the papers presented in this volume, it is clear that this discipline is led mostly by amateurs or by freelance workers and scholars who do not work in any institutional research centre. Of the seven Italian scholars who have put their signature to articles in this volume, not one has a permanent institutional role. Without any doubt the quality of the research of some of them should have official recognition. This is particulary evident looking at the scientific publications about medieval galleys. In fact, three of the most famous experts on this topic (S. Bellabarba, A. Chiggiato and M. Bondioli) are Italian, but are "amateur"-scholars (!).

A reformation is needed in the sector of cultural resource management. 13 years after its discovery, nothing has been done to preserve the interesting 13th century (?) hull of the galley which lies a few meters from the beach of Camarina in Sicily (Di Stefano, 1991). But positive news comes from the same island: at Marsala, finally, the superintendency has assigned to specialists from the Centre of Roskilde the project of restoring and re-exhibiting the Punic ship.

Other conservation projects are perplexing. The best known event is that of the sewn hull recovered at Valle Ponti in 1981 which has not yet been restored nor shown to the public. And what about the fishing boat of Ercolano, found in 1982 but never exhibited, and the Arabian-Normann wreck found in Marsala, dismantled but never restored? The Marsala hull would be a very important source for the study of medieval Mediterranean ship construction. Conservation of the Herculaneum boat should start in 2002, but what about the others?

A laboratory specialized in the wet wood conservation is most desirable for the conservation of finds from all over the country. A very intelligent idea under NAUSICAA's direction proposes to build it in the *Arsenale*.

It is necessary to make suitable arrangments to decide on the institutional place for nautical archaeology not only from a scientific point of view, but also because of great interest people have in it. Foreigners have always been interested in the nautical heritage of Italy but nowadays Italians are also becoming fully conscious of its great importance. This is evident in the great interest in the wrecks of Pisa and of S. Marco in Boccalama in Venice.

It is not by chance that in recent years incresing number of "replica" of ancient ships have been built, unfortunately not always according to scientific methods. In Italy we are living a paradoxical situation. The great interest in ancient ships had led to a great number of "replica" projects, but they are not always devised after rigorous study of the ancient building methods, *conditio sine qua non* to arrive at a serious proposal.

On the other hand, there are some worthy projects such as the one relating to the rebuilding of a Nemi ship. The superintendency of Lazio is now promoting a reconstruction which can be based on the rich documentation left by Ucelli. If a scholarly analysis is now undertaken, it should be possible to build an authentic replica.

Personally I am optimistic for the future, considering this phase as a formative one. After the great popular entusiasm for the recent important discoveries, a phase of institutionalisation must be conducted by the Ministery of Beni e Attività Culturali with the employment of archaeologists specialising in ship construction, with the organization of a centre equipped to operate on wrecks, on land and underwater, and with the creation of a laboratory for the conservation of wet wood. As for the University, it should consider creating positions for the teaching of nautical archaeology and to promote reseach in this field.

Is it a dream? It could be, but in some countries these dreams became reality. Why not in Italy?

Notes

1 The final publication includes a number of useful drawings: a deck and sheer plan, a longitudinal section, a midship section, and all the lines of the first vessel. We also have some important construction details of the second vessel.

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3. The Arsenal of Venice and the Art of Building Ships

Mauro Bondioli

The Arsenal of San Marco has long been a subject of particular interest to scholars who have explored its architectural, political, social and economic aspects. It is also necessary to emphasize that the Arsenal was above all a center of production, yet the technological context constitutes one of the least famous features of this Venetian institution.

In many historical studies, the technological capability of the Venetian masters has been confused with production capacity and the attainment of a highly sophisticated organizational structure. But the construction of many ships in a coordinated way does not necessarily imply that the ships are of higher quality than those produced elsewhere or that more innovative designs have been used. No one is now in a position to know if the most important pre-industrial complex in the late medieval/Renaissance Mediterranean basin in fact employed designs or techniques more advanced than those in use in other shipbuilding centers. Even through the economic study of maritime commerce or the tactical analysis of naval battles (based on reports that are rarely exact and often biased by patriotic pride), we cannot judge if Venetian ships were inherently better than those constructed by the masters of the Ligurian shore. Moreover, it must not be forgotten that primary accounts of the workings of the Arsenal illustrate an internal situation often far from the amazing efficiency that we are usually given to imagine. We cannot escape the reality that the Arsenal, in the course of its long history, developed political and social aspects at odds with the logical requirements of production, becoming a den of patronage and corruption, as still happens today in state-run businesses.

We are also aware that, at the beginning of the 15th century, masters of Greek origin were employed in the Arsenal and that they were particularly skilful in the construction of the *galee sottili*, the backbone of the naval fleet (see Lane, 1965; Rossi, 1996a; Bondioli, Penzo, 1999). One of these masters, Giorgio Palopano, had already been a master in the Venetian Arsenal for 11 years when Constantinople fell to the Ottomans in 1453.[1] Does the presence of these Greek masters indicate that, at the height of their commercial and territorial power, the Venetians did not know how to construct this most essential of ship types and that they entrusted their maritime defense to foreigners?

And what are we to think of the denunciation in 1554 of 27 shipbuilders of the Arsenal, who, despite their high salaries, did not know how to build *galee sottili* but farmed the task to other colleagues, enticing them with gifts[2]? These assignments were given by the *Patroni* to the Arsenal and the offenders surely had their complicity. Are these sporadic events or testimony of customary normality? Where is the highly praised Venetian skill? And the Arsenal itself, the heart of the Venetian state, was it indeed the new Babylon, the eighth wonder of the world that astonished visitors, or more the overgrown garden and nest of vipers described by Baldissera Drachio Quintio in his *Visione*?[3]

We have neither the presumption or the time to examine in detail the centuries of Arsenal history, which would require deeper studies that go beyond our own abilities. We will therefore limit ourselves to tracing some general lines of inquiry.

At the time of its foundation, that is when the Arsenal was designated as a specific area and its functions were limited to simple warehousing and later shelter and repair of a small number of vessels, technical knowledge remained the preserve of private shipyards. In this situation, the shipbuilder, owner of his own shipyard (*squero*) was also the repository of ancient traditions and the engine of technical progress. He contrived on his own account to find the best technical solutions to the demands posed by his customers, either through his own ingenuity or through imitation of models from other places.

The Venetian state, still not directly involved in its own technological infrastructure, entrusted the construction of its own ships to private yards. It is probable that in this period the development and transmission of technical knowledge was faster and more continuous than we have previously imagined, occurring as it did in a small and tightly knit local community of builders. One indication of the level of communication is the completion in four months in 1172 of a hundred galleys. This positive outcome may well have emboldened the Doge to agree in 1187 to build a fleet of 40/100 galleys in six months for the Byzantine Emperor Isaac II Angelis. Between 1201 and 1202 Venetian talents were again put to the test, building and fitting out another great fleet (Concina, 1988:9–12).

Even though the naval types of that time were quite heterogeneous and largely unknown to us, a large proportion of the hundred galleys of 1172 were probably simple *monoremes*. This is less certain of the galleys of 1202. In any case, whether then or somewhat later, it was still the masters of the private shipyards who were responsible for the complex solutions necessary for the evolution of the galley from *monoreme* to *bireme*. In the first half of the 13th century, when the Arsenal assumed a productive role, albeit modest, the organizational structure was probably modeled on that of the private yards. Thus arose the *proto dei marangoni* (literally the master of the carpenters, the title the master shipwright assumed therafter), expert in shipbuilding and logistic coordinator of the labor force. These men in turn submitted to the authority of the *Patroni* of the Arsenal.

Without going too deeply into a detailed analysis of this period, it is interesting to note the continuing Venetian concerns in the administration of shipbuilding:

- to maintain a large force of skilled shipbuilders, who would otherwise be inclined to leave for other, more favorable locations, emigration was prohibited from 1227;
- to assure in a continuous, even coercive fashion the employment of shipbuilders working for the state;
- to guarantee regular commercial traffic in spite of the difficulties encountered by private ventures in preparing galley convoys.

These are only some of the factors that encouraged the Venetian state to think of the Arsenal as a place of construction, and in 1302, with the decision to build all state galleys in the Arsenal[4] and to develop its structure, the beginnings of a technological split can be observed between the builders working in the stable environment inside and those subject to the economic vicissitudes of the outside world. In a period in which there was still not a clean conceptual separation between the naval and commercial functions of ships, the builders of the Arsenal followed the Senate's directives motivated by economic politics and warfare, concentrating on the construction of long ships. The builders in the private yards were more directly affected by market forces yet somewhat cut off form the great state-run commercial enterprises, and thus concentrated on smaller vessels and round ships.

The appearance of the trireme *galea grossa* in a period often characterized as a nautical revolution represents the truly innovative design effort. It is not our purpose here to discuss the place of Venice in the introduction of the *galea grossa* (attributed by some to the Venetian Demetrio Nadal in 1294) (Casoni, 1847) or the technique of rowing three to a bench (with which the Genoese admiral Benedetto Zaccaria seems to have been experimenting as early as 1290 (Lopez, 1933: 169; Minervini, Ed., 2000: 255).[5] What is of interest to us here is the rapidity with which the news of new innovations spread in the Mediterranean and how shipbuilders in large-capacity yards responded.

Even if it is true that trireme (three men to a bench) rowing was learned from the Genoese after 1290, Venice also tried similar experiments. In 1316 it had some success with *quadrireme* rowing and some even wished to try rowing with five oars to a bench.[6] If the Venetians were the first to construct the *galea grossa*, we must also record its presence in 1315 in the Arsenal of Barcelona, together with some *galee bastarde* and *galee sottili* (Eberenz, 1975: 155). These are evidence of the ultimate evolutionary stage of the 12th century galley, as well as the intermediate types necessitated by the appearance of the *galea grossa.*

These various bits of evidence should not confuse us. The appearance of one new technical solution no doubt encouraged the appearance of others, both alternatives and imitations based on personal observation or second-hand description. It is moreover necessary to reflect on the possibility that in the 13th century or before, there existed a common Mediterranean *koine* of design principles and construction methods. Also, there may have been, in effect, a two-tiered system, where a more advanced method was known to a few masters and a more modest level of expertise was practiced by a larger number.

Obviously, we cannot demonstrate that this actually happened, but it should not be forgotten that all shipbuilders did not possess the same level of skill, social standing, or technical preparation. Each master was an individual, and late medieval shipbuilding was an art based on empirical experience in both the shipyard and in navigation, inspired by instruction from previous masters with their own individual experiences and preferences. Great events, such as the Crusades, as well as the continuous cultural exchanges resulting from long-distance commerce, probably also stimulated new technical solutions and contributed to the methods of construction.

Perhaps general rules already existed as references, but the possibilities for shipbuilders to introduce personal variations were very wide. Great conceptual differences in the construction process could co-exist. Once completed, the finished products might be nearly indistinguishable and come be identified with the same name: *quae vulgo galae dicuntur.*[7]

It is also necessary to specify that the ability of the shipbuilders to plan *ad hoc* was effectively negligible. Normally they used already tested models with good possibilities of success and any modifications they might make were necessarily extremely small, resulting in very gradual change, if any. To disregard the traditional model in any significant way meant be uncertain of the final result. In time, however, these small mutations, even if slow, could result in constructive criteria that would never have been attributed to the original model. For example, the proportions specified in the original design might be so altered in a derived design as to be unrecognizable.

Finally, it is necessary to consider the aggregate loss in the collective memory of the historical and technical reasons for specific design decisions, even as they were transmitted to new generations of shipbuilders. We think here not only of the great events, such as war, migration or plague, such as the Black Death that swept away 3/5 of the Venetian population in 1348, but also of random small events, such as the untimely death of a master, before he had the opportunity to tell his apprentices all of the secrets of his art.

In this early period, the transmission of knowledge was oral, from father to son and master to apprentice.

In the slow process of experimentation in search of improvement in his own work, the shipwright was limited to a certain degree by his upbringing and education, but brought his own contribution to the technical patrimony of succeeding generations. Still, it is unlikely that he would pass on to his son or apprentice truly useless of obsolete practices. At the same time, no matter how much versatility was included in his education, the Arsenal's specialization in a few ship types meant that not all of the information acquired during an apprenticeship was put to regular use. This lack of reinforcement meant that some elements inevitably did not get passed on.

The same method of construction, recorded in the form of annotated tablets and moulds, preserved the greater part of the essential information without recording the fundamental reasoning behind it. A lifetime of experience could be collected in the form of a few patterns and instruments and explanatory notes or reasoning could be dispensed with. This effectively wiped away the memory of why certain decisions had been made, and even participation in the construction of a hull would not allow the most skillful of students to grasp the mysteries of the creative thought of the master. It is, in fact, easier to repeat a particular action than to understand fully the reason behind it.

We do not have a listing of the *proti dei marangoni* of the 14th century, and therefore we do not know when it became common practice to appoint new *proti* on the basis of blood ties to their predecessors, as happened in private yards. When it did happen, it created a technological oligarchy that perhaps strengthened the traditional tendency, itself a response to the external influences trying to wear away this new-found power.

Nonetheless, things began to change. We do not know exactly when it was felt necessary to establish a new office as an alternative to the *proto dei marangoni*, before or after the war of Chioggia against the Genoeses, but the *proto dei galee sottili* Teodoro Baxon (of Greek origin) was already old at the beginning of the 15th century and is remembered as one of the best constructors of his time.[8] His galleys were preserved as examples for new constructors well after his death in 1407[9]. At his death, the Senate immediately sent a representative to Rhodes to convince his grandson, Nicolò Palopano, to take up the family trade.[10] This offer was refused, and it was another 17 years before, on 15 December 1424, Palopano finally accepted.[11] Shortly before his arrival, the old *proto dei marangoni* Giacomello di Bernardo (elected in 1406, died June 1424) had been succeeded by his son Bernardo di Bernardo.[12]

The vicissitudes that faced the two constructors, Bernardo and Palopano, are not important here, but in March of 1434, Palopano was elected *proto delle galee sottili*,[13] and in June of 1437, the Senate decreed that all galleys, *grosse* and *sottili*, had to be constructed to the plans of the same Palopano.[14] Even though the Greek master died a short time later, his triumph coincided with the ejection of Bernardo di Bernardo from the arsenal.[15] The official cause is unknown, but we may imagine. The question is, is this because the Venetians had a need for the Greek shipbuilders?

We have already assumed two factors: the excessive tendency toward traditionalism, a closing off of influences from the outside in an attempt to maintain privileges (both personal and corporate) and the loss of precious information in the collective memory. To these must be added a third element, perhaps decisive. The great efforts that the Arsenal made in the construction of the *galee grosse*, for commerce and the transport of pilgrims to the Holy Land, involved the development of different techniques. It is possible that this diverted energy from the development of the *galee sottili* and thus necessitated or encouraged the employment of the Greek masters, who came from a region that had not experienced the same stimuli. They had therefore maintained the ancient traditions or had developed compatible construction systems independently. These may have varied from the Venetian norm, but been more suitable to the military requirements of Venice.

From some of the evidence we have found in our studies, we feel that the technological expertise of Nicolò Palopano was more appropriate to the older bireme galley than to the trireme. But, as it often happens in the adoption of technological innovations, a better interim result is attained with an optimized version of the old technology than with an unperfected version of the new. By this we mean that it is possible to suppose that the Greek masters could have achieved a temporary advantage by a technical compromise for the construction of the *galee sottili* that, while not especially modern, was a high development of an older type. At the same time, the Venetians, exploring new vessel types and methods of construction, may have obtained an optimal result for some types that was not readily applicable to others.

With the death of George Palopano, son of the aforementioned Nicolò, no other Greek shipwright ever attained a position of such importance in the Arsenal, and the office of *proto delle galee sottili* vanished. The Venetian and the Greek schools had finally melded.

The situation changed dramatically between the end of the 15th century and nearly the entirety of the 16th. This period is characterized as one of the heaviest naval production, so that the old figure of the *proto dei marangoni*, who could no longer keep up with tens of ships at a time, was assisted first by two deputies, the *sottoproti* and then numerous foremen or superintendents (*capo d'opera*). A similar solution was adopted at the administrative level, with the introduction of the office of the *provveditori* to the Arsenal (see Rossi, 1996b),[16] in support of the two *Patroni*.

The 16th century is a period of great importance to the Arsenal and deserves more than these few remarks in order to depict some of its workings more clearly. Among the principle developments was the introduction (perhaps in the end of the 15th century) of a kind of contract between the state and the superintendent. Such contracts were called *sopra de si* (literally " over them") and these contracts have never been studied, either in terms of the legal form or their application. The essential terms established that a constructor engaged himself to construct on behalf of the Arsenal one or more galleys on the basis of a compensation scheme fixed in advance.

Such a solution increased the logistical problem of organizing the workforce, but it also introduced remarkable problems of corruption and great confusion. Many ships once begun were left incomplete as the Master ran to implore the Senate to raise his pay. Even if the Senate bowed to this type of blackmail, in many cases the master still failed to finish the work or completely hastily.

The considerable increase in naval production as well as the continuous competition between shipbuilders facilitated the superintendent's opportunities to construct the designs of other colleagues, even to the point of promoting cronies who were not true builders. The interest of scholars and some of the nobility in particular aspects of the construction process, an interest not previously seen, actually contributed remarkably to progress in the Arsenal. We would like to cite here the great contribution of Vettor Fausto, who first introduced the use of algebra in ship design. There is also an exchange of letters between Giacomo Contarini and Galileo Galilei on the function of oars and their motion.[17] Unfortunately, these contributions also introduced great confusion, because everyone felt authorized to provide instruction, whether it was sound or not, the shipbuilders.

By now, of the shipbuilders' secrets, little remained to be defended. Something of a new order was about to appear and it would soon sweep away the remains of a technical culture almost a thousand years old. A new order that some called *science*.

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Notes

[1] Archivio di Stato di Venezia (A.S.V.), Senato, Deliberazioni mar, reg. 1, f. 77r.

[2] A.S.V., Patroni e provveditori all'Arsenal, reg. 10, f. 28v.

[3] A.S.V., Archivio proprio Contarini, b. 25.

[4] A.S.V., Maggior Consiglio, Deliberazioni, reg. 8, ff. 23r–24r.

[5] Marino Sanuto, called Torsello, *Liber secretorum Fidelium Crucis super Terræ Sanctæ recuperatione et conservatione,* in Gesta Dei per Francos, Hanoviæ 1611, Liber II, chap. IV, 57: *"Sciendum quod in MCCXC anno Domini, quasi in omnibus galeis quæ transfretabant per mare, duo in banco remiges remigabant: postmodum perspicaciores homines, cognoverunt quod tres possent remigare remiges super quolibet prædictorum, quasi omnes ad præsens hoc utuntur".*

[6] Marino Sanuto called Torsello, *Liber secretorum Fidelium Crucis*, cited, Liber II, chap. IV, 57,65, 77.

[7] *Historia rerum in partibus transmarinis gestarum a tempore successorum Mahumeth usque ad annum domini MCLXXXIV. Edita a venerabili Willermo Tyrensi Archipiscopo,* in Gesta Dei per Francos. Hanoviæ 1611, *Historia rerum in partibus transmarinis gestarum*, Lib. XX, chap. XIV, 982: *"Erant sane in præfato exercitu, naves longæ, rostratæ, gemini remorum instructæ ordinibus, bellicis usibus habiliores, quæ vulgo galæ dicuntur, centum quinquaginta".*

[8] A.S.V., Senato, Deliberazioni miste, reg. 46, f. 76r. A.S.V., Patroni e provveditori all'Arsenal, b. 566, *Quaternus in quo scribuntur omnes salariati nostri Arsenatus*, f. 7v.

[9] A.S.V., Senato, Deliberazioni miste, reg. 52, f. 72r. *Ibid* reg. 55, f. 81v. *Ibid.*, reg. 57, f. 209v. *Ibid.*, reg. 58, f. 56r.

[10] A.S.V., Senato, Deliberazioni miste, reg. 47, f. 155r.

[11] A.S.V., *Quaternus...*, cited, f. 16r.

[12] A.S.V., *Quaternus...*, cited, f. 14r.

[13] A.S.V., Senato, Deliberazioni miste, reg. 57, f. 201r.

[14] A.S.V., Senato, Deliberazioni miste, reg. 60, f. 17r.

[15] A.S.V., *Quaternus...*, cited, f. 14r.

[16] A.S.V., Senato, Deliberazioni mar, reg. 1, f. 129v.

[17] A.S.V., Archivio proprio Contarini, b. 25.

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4. Neolithic Watercraft in Greece: Circumstantial Evidence and Serious Guesses

Christina Marangou

In spite of a background of intense aquatic mobility in the Neolithic Aegean Sea, as well as across or along inland waters, concrete evidence from Greece about the craft itself being used only consists of some clay models and a few outlines of lake craft (see Crumlin-Pedersen, 1991).

Both categories are attested at Dispilio (lake of Kastoria, W. Macedonia, at 620masl; Hourmouziadis, 1996), although dating from different phases. The outlines belong to the latest phase, end of Late Neolithic (LN), or beginning of Final Neolithic (FN) (probably *circa* 4500 BC cal.), while the models were found mostly in the oldest excavated strata (C14: 5260–5360 BC cal.), dating from the transition from Middle Neolithic (MN) to LN. Other, mostly LN, models have been identified in neighbouring areas, Thessaly, Albania, Serbia and FYR of Macedonia (Marangou, 1990; 1991; Central Europe: Höckmann, 1996).

Boat models measure from 6 to 28cm, more frequently 10–25 cm (overall length), 2.5–14cm (breadth), and 2–7.2cm (depth). Similar types are made in different sizes, as it happens with other models and figurines. The choice of the boat theme shows that real boats were familiar, all the more so, if the types variance reflects reality. The precise reasons for this choice are unknown, but the fact shows at least involvement of modellers or users with boats, even if just for choosing a shape for a container.

Not least because of the small number of examples and the limited time span of their occurrence, diversification of shapes is astonishing, suggesting a corresponding early differentiation of real watercraft, and therefore local traditions and/or diverse specialised uses on the same site. Without excluding *cultural* preferences, divergence could arise from distinct structural characteristics and technological possibilities, including because of different raw materials.

Some models may represent wooden prototypes: all possible sub-types of dugouts, even paired logs, still used in the beginning of this century in lakes Ohrid and Megali Prespa and in Albanian rivers as animal cargoes and ferries. Dugouts were used with punts or paddles in the Prespes lakes till after 2nd World War and even later in the Albanian part, subsequently replaced by plank boats (Katsadorakis, 1996b: 29–32). Dugout models come from LN Thessaly (A. Sophia, Otzaki(?), Platia Magoula Zarkou (PMZ)) and LN Dispilio, double dugout models from Pelagonia and Albania.

Earlier models (mostly end of MN–beginning of LN) at Dispilio (Marangou, 2001; in press), clearly are not simple *monoxyla*. Comparatively deep, with slightly raised, pointed ends, a vertical rib on one extremity, raised sides amidships, sometimes a wavy gunwale, they suggest particularly elaborated dugouts, or watercraft with a frame on which hide (see Hornell, 1946: 91–108) or bark were fixed. In fact, some Indian American bark canoes present this irregular gunwale (Adney *et al.*, 1964: 95, 97; see Rieth 1993: 167, pl. 128, 19, 'canot de Kamtchatka').

All possible raw materials for building small craft were available locally: oak and pine were extensively used in Dispilio for house construction. Modern plank boats are often in elm or chestnut. Hide and fur of large animals, attested from bones, were used in Neolithic houses; an astonishingly large clay horned head at Dispilio and smaller animal figurines in various sites show the importance of cattle; curing of hide and skin is attested since the Neolithic (Groenman *et al.*, 1999). Ancient authors mention hide boats or rafts in the North of Greece, used in rivers, or for short sea distances. Even bark boats were possible: birch existed in the Neolithic in the area, about 150 m higher than the Kastoria lake (Marangou, 2001: 198). It still exists in the mountains around the Prespes (Katsadorakis, 1996a: 118). Reeds were obviously the easiest raw material at hand by the lakes, and willow or hazel branches were available for frames. Stone axes, abundant everywhere, have left traces on Dispilio posts; bone tools used for hide are common, and basketry is frequently printed under the bases of Neolithic vases. Wooden planks assembled with pegs were found in Early Neolithic Prodromos in Thessaly, plank floors at Servia (Demoule *et al.*, 1993) and planks were possibly used in the latest Dispilio Neolithic. Various materials have been combined in the recent past: planks with hollowed logs –

stabilisers in Ohrid lake boats, double dugouts were made of hollowed logs and planks in the Prespes (Stankovic, 1929: 83). In Megali Prespa, boats, disappeared today, were made of pine bark combined to planks (Stankovic, quoted by Katsadorakis, 1996b: 30).

Little can be said on the chronological evolution of Neolithic boat types. Clay models representing wooden craft could be later than possible hide- (or bark) boat models. The A. Sophia (succeeding LN Otzaki) and the advanced LN Dispilio dugout models are preceded by end of MN Dispilio 'coracle' models. The Otzaki example has an animal head with perforated eyes modelled on its preserved end; its exact shape (*spitzoval*) is not clear from the publication;[1] it could either represent a dugout with *oculi* on the prow or an animal hide boat. Differentiation of watercraft types could also be local, since the PMZ early LN model (see further) is shallow or flat like a dugout or a raft.

If this perceptible variability of craft types and possibly materials is real, the question remains – was the choice structural, technical, functional, economic, or cultural, social, symbolic? Different boat types might be intended for different purposes, for permanent or temporary craft, or for various practical uses, depending on the specific aquatic environment and the Neolithic communities' economic needs.

Involvement with aquatic matters is obvious when we look at the environment of the areas where boat models were found. Specific local conditions may have influenced the choice of a watercraft type. In Thessaly, PMZ, Otzaki and A. Sophia (LN), in the frequently flooded Peneios river plain, are located at short distance from the northern bank of the meandering river, PMZ being now at 800 m from it (Gallis, 1992: 225, n. 43). In the Holocene its maximum bed breadth would have attained 2 km, after which it would flood (Helly *et al.*, 2000: 12). Neolithic settlements profuse on both sides of the river. Its strong current was used till recently for the transport of wood logs in series of rafts (Peneios, 1998: 19). Crossing was difficult and dangerous; flat barges-rafts of logs were used, pulling on an iron rope, secured on trees on both banks (Peneios, 1998: 20, 81– 82). Plank boats were used by fishermen (Gourgioti, 1977). Models of flat boats or rafts are not out of place under such river conditions (see Rieth, 1998: 56–62). Paired logs models occur in a number of lake and river sites (Pelagonian plain, SE Albania), in a region where reciprocal influences in other fields than boat types are also attested, for example in pottery and figurines styles (cultural group Suplevec-Bakarno-Gumno). Double logboats were still used in the same area around 1900. As about coracles, they would not be out of place in the Kastoria lake area (incidentally, a modern fur industry centre).

Local aquatic conditions, large rivers with strong current, smaller or larger lakes, specialised uses, such as ferries, cargoes, fishing boats etc, and practical considerations, such as carrying light bark or hide boats from one lake to another (for light dugouts see Arnold, 1998: 75), may impose certain boat types or material choices. Furthermore, local variance and persistent conservatism of inland watercraft are well known till present times (for example Katsadorakis, 1996b: 30–32). Till recently, fishermen fishing in 'foreign' lakes brought with them their own boats. This happened even with USA immigrants from Ohrid, who used Ohrid type boats, specially made on command, in American lakes (Stankovic, 1929: 88).

Keeping in mind that there may be more unidentified specimens, and that excavations at Dispilio continue,[2] boat models are not a persistent Neolithic feature in these sites, but rather characterise a particular time span. This does not exclude possible older or later examples from having different functions in other periods. However, the PMZ 'cult scene' dates from the very beginning of the LN; most Dispilio models, as well as several oval, 'boat-shaped' vessels, date from the end of MN and the beginning of LN, when architectural methods are different from later ones. In this phase, the houses were built in a marshy environment, their floors consisted of layers of clay, wooden beams and stone structures. In the latest MN of Otzaki, a change in architectural customs is mentioned, as building remains show the use of posts, in contrast to all previous mud brick houses (Andreou *et al.*, 1996: 552). Would then the modelling of boat models result from some climatic-environmental situation at the end of the MN and the beginning of the LN, for example for protection against natural flaws? Figurines are also much more numerous then, than in succeeding periods.

In fact, about a millennium later (end LN–FN), hardly any boat models and very few figurines are found at Dispilio. However, three boat outlines were discovered in two different strata in the periphery(?) of the settlement; a shallow ditch surrounds the excavated area to the west of the outlines. Houses consist now of land structures of clay bricks and floors, but the precise location of the lake is unknown. The outlines (Marangou, 1999; 2001; in press) (Fig 4.1A–C) are concentrated in two contiguous trenches, possibly close to a once fishing area: an intermediate stratum contained fishing weirs. It is not clear, though, whether the boats were abandoned, under construction or in use.

Again, there are at least two different boat types, as one or two of their ends are pointed. All three outlines have similar orientations (SE–NW) and dimensions.[3] Two of them (A–B; dugouts?) were found in the same stratum, one behind the other. The third one (C), two strata under B, is very wide, partly due to bad preservation, and has a transversal element (thwart?) close to the pointed preserved end. It could be a dugout, but also the frame of a hide boat, as hide is not preserved. Near the pointed end of A, which has not been excavated, burnt traces are visible, and a clay feature (hearth?) is located amidships, close to port side of B (detailed description: Marangou, 1999; in press). Traces of other badly preserved outlines possibly existed originally on the same spot, in intermediate and lower strata, similarly

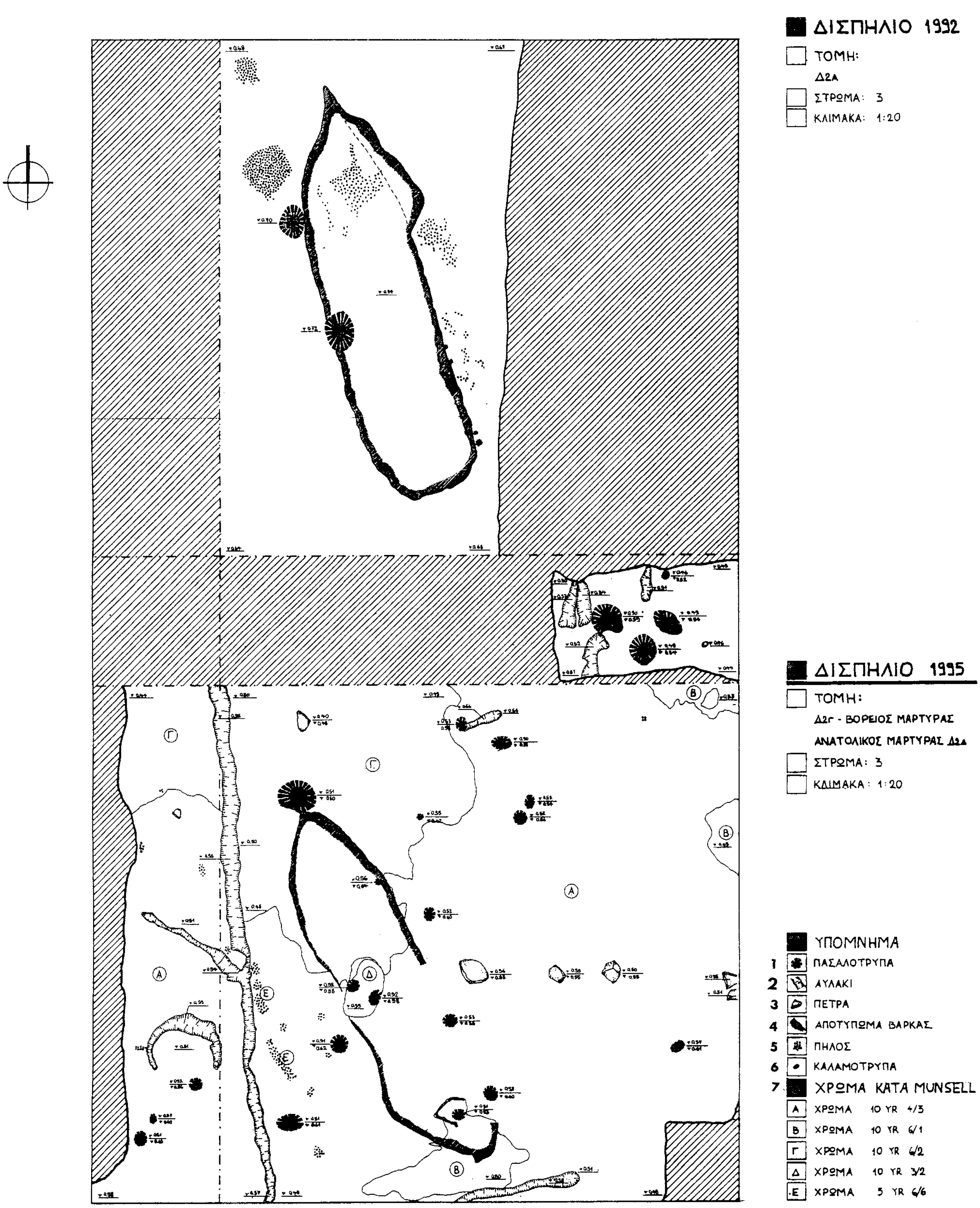
ΔΙΣΠΗΛΙΟ 1992
ΤΟΜΗ: Δ2Α
ΣΤΡΩΜΑ: 3
ΚΛΙΜΑΚΑ: 1:20
ΔΙΣΠΗΛΙΟ 1995
ΤΟΜΗ: Δ2Γ - ΒΟΡΕΙΟΣ ΜΑΡΤΥΡΑΣ ΑΝΑΤΟΛΙΚΟΣ ΜΑΡΤΥΡΑΣ Δ2Α
ΣΤΡΩΜΑ: 3
ΚΛΙΜΑΚΑ: 1:20
ΥΠΟΜΝΗΜΑ
1 ΠΑΣΣΑΛΟΤΡΥΠΑ
2 ΑΥΛΑΚΙ
3 ΠΕΤΡΑ
4 ΑΠΟΤΥΠΩΜΑ ΒΑΡΚΑΣ
5 ΠΗΛΟΣ
6 ΚΑΛΑΜΟΤΡΥΠΑ
7 ΧΡΩΜΑ ΚΑΤΑ MUNSELL
A ΧΡΩΜΑ 10 YR 4/3
B ΧΡΩΜΑ 10 YR 6/1
Γ ΧΡΩΜΑ 10 YR 6/2
Δ ΧΡΩΜΑ 10 YR 3/2
E ΧΡΩΜΑ 5 YR 6/6
A
B
Γ
Δ
E

Fig. 4.1 Final Neolithic boat outlines from Dispilio, Western Macedonia, Greece (drawing 1:20 by Vasso Tselika). Excavation square side: 4 meters. A–B. Squares Δ2A, Δ2Γ, excavation stratum 3. 1. Post-hole; 2. 'Ditch' or 'channel'; 3. Stone; 4. Boat outline; 5. Clay; 6. Reed-hole; 7. Munsell Colour Chart numbers.

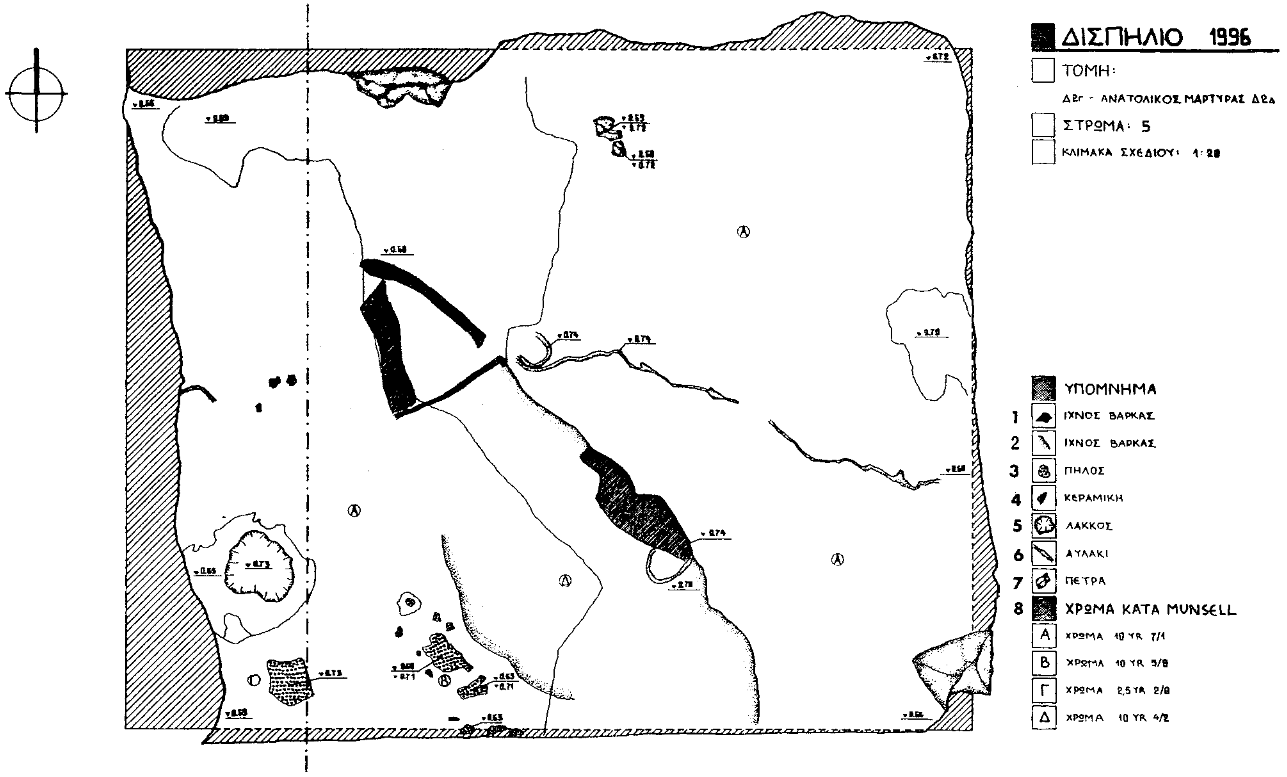

Fig. 4.1 C. Square Δ2Γ, excavation stratum 5. 1. Boat outline; 2. Boat outline; 3. Clay; 4. Pottery; 5. Pit; 6. Ditch or Channel'; 7. Stone; 8. Munsell Colour Chart numbers.

oriented. All were of course small, lake-craft, probably used for fishing, like present *manoxyla*.

Exceptionally, some models suggest possible sea-craft types. A unique MN (?) asymmetric boat model from Tsangli (Thessaly) might attest an evolved type (Marangou, 1991; 1996), such as an extended dugout (see the *Verup 1* Neolithic dugout: Arnold 1995: 43), or an elaborate hide boat. It is divided in two compartments by a fitted transom or a bulkhead and disposes of a "keel" element along its base. Tsangli is located near a passageway from the western plain through the low hills to the Pagasetikos Gulf. Alternatively, this could be lake craft, as Tsangli was not far from the eastern plain and lake Karla, on which storms were frequent. Till its draining (1962), fishermen from the surrounding mountains used a particular type of flat boat. The banks were densely occupied by prehistoric sites (Gallis, 1992; Helly *et al.*, 2000) and a Neolithic settlement was partly excavated on the Hatzimissiotiki island in the lake (Grundmann, 1937). Experience gained from navigation in the lake, which communicates with the eastern plain and the Aegean, could be tested subsequently in the sea.

Besides the Tsangli type, other types of seaworthy craft are possible. According to ethnographic and post-medieval evidence, reed boats – the *papyrella* (Tzalas 1989) – and paired logs -the Athos monks' fishing boats (Marangou, 1991) – could have been used in the sea, at least for fishing. Furthermore, as noted above, ancient authors describe crossings in hide rafts and boats.

Contextual information about boat models is rare. However, they have occasionally been found in small groups (Dispilio), related to large numbers of vases, including fine ware, clay figurines or shell, bone and stone jewellery, and burnt structures (Marangou, 2001; in press). This concentration suggests redundancy of symbols in ritual, non excluding practical use. Tools, vessels and house equipment or decoration may be anthropo- or zoomorphic, and the boat shape makes a convenient container. Neolithic food storage is occasionally connected to symbolic objects, fine pottery would have been used on social events along with food consumption, and houses attest domestic ritual and everyday activities in parallel. Possible practical use of models would illustrate this inter-penetration of utilitarian and symbolic aspects, but this cannot be proved for the moment, as long as the appropriate analyses are not made. On the other hand, since boat models and figurines are not regularly distributed in Dispilio, their selective occurrence may suggest special occasions in specific places for particular social groups.

The exceptional discovery of some figurines and a possible flat, incised model of a boat (alternative interpretations: Marangou, 1991) with upturned ends in a model house, by the hearth of a LN house, in PMZ (Gallis, 1985), in Thessaly, may represent such an occasion. If the model represents a real boat or raft, it is not in scale with the humans or the house. The object is not unique: several other similar surface finds are still unpublished. Another boat model, as well as several figurines, were found in a LN house at Selevac (Serbia), not far from Danube tributaries (Marangou, 1991). The cremation cemetery close to the PMZ settlement, posterior to the earlier Neolithic alluvium, is clearly segregated from the living space and two categories of grave goods are distinguished (Andreou *et al.*, 1996: 555–557).

Concluding, we may note that both real and symbolic functions attest the significance of watercraft, in a period when distances and natural barriers, in particular water, counted crucially, although precise information and certainty are lacking. As about iconic or symbolic uses of Neolithic watercraft, boat models, as other models or figurines, would belong to one of the semiotic systems, abundant in Neolithic everyday space. Although we still do not know in what craft obsidian from Melos, as well as plants and animals and cultural habits from the East ("Neolithisation") travelled across the Aegean, or how tuna was fished in the Stone Age, it seems, nevertheless, that the possible vehicles could have been diversified.

Acknowledgements

The author is particularly grateful to Ole Crumlin-Pedersen for precious advice on primitive craft and help during a stay as invited scholar in Roskilde (1997). Thanks are due to George Hourmouziadis for entrusting me with material from the Dispilio excavations, also thanks to Vasso Tselika for drawing the plates, and Duska Urem-Kotsos for helping with Serbocroatian.

Notes

[1] Precise dating of the Otzaki material has also been called into question (Gallis, 1992: 116–117; Andreou *et al.*, 1996: 552): it includes early LN, Classical Dimini LN and FN.

[2] This is not the final publication. Only material found till 1998 has been included.

[3] Length: 3.00; 3.30; 3.50 m; max. breadth: 0.73; 0.80; 1.40 m.

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5. Sewn Planked Boats from Early Dynastic Abydos, Egypt

Cheryl A. Ward

Introduction

In 1991, archaeologists for the University of Pennsylvania–Yale expedition to Abydos working east of the Second Dynasty funeral monument of Khasekhemwy (2650 BCE) uncovered 12 low, mudbrick structures, some still substantially covered with white plaster (O'Connor, 1991). Measuring 19–26 m long, and under 3 m wide, the structures were identified as boat graves. Both a test excavation and the outline of wooden plank edges in a typical boat shape at the surface of the structures confirmed the identification. The 1991 test excavation in Boat Grave 10 (BG10) revealed the profile of a flat-bottomed hull with angled sides, set into a mud plaster-lined cutting in the ground, and running from northeast to southwest (Fig. 5.1).

A return to BG10 in May, 2000, under the field direction of Matthew Adams, focused on excavating the hull from the 1991 section to the eastern[1] end of the mudbrick grave, a distance of about three meters. At the same time, the other 11 graves were uncovered and evaluated in order to identify a candidate for full excavation in 2003. Exploratory work South of BG12 revealed two additional boat graves, bringing the total to 14 (O'Connor, Adams, 2001).

Working from the section cut in 1991 to the east, we uncovered approximately 2.6 m of the boat, including bottom and side planking from its eastern terminus. A thick layer of matting above the hull and its fastenings suffered almost complete degradation by insects, but originally was up to 3 cm thick. The boat was filled with one to four layers of mudbrick and mortar above the matting. The sheer strake's upper edge was left exposed at the time of burial. Mudbricks support the sides of the hull, which, in several areas, slumped and took on the shape of the bricks beneath it. Finally, the entire structure was plastered. The mudbrick structure has a rounded end that includes the base of an upright, substantial, round-sectioned timber. O'Connor and Adams (in press) suggest this may be the remains of a flagpole, a common component of later ceremonial sites.

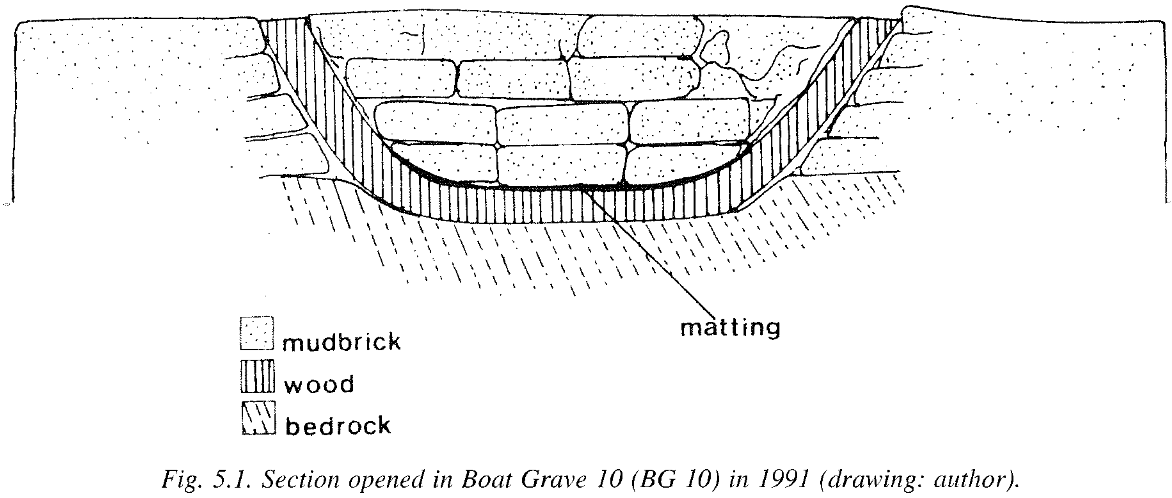

Fig. 5.1. Section opened in Boat Grave 10 (BG 10) in 1991 (drawing: author).

The hull

The results of preliminary analysis and interpretation are presented below. Despite the presence of intrusive burial pits that destroyed part of the hull, significant portions of the planking remain. The excavated area included planks from each side and the bottom of the vessel (Fig. 5.2). The boat is composed of straight-edged planks fastened together by transverse lashing through channels. It is flat-bottomed with an angular chine and rises abruptly towards its end. No floor timbers or beams were used in this portion of the hull, and there is no evidence for them elsewhere at present.

The condition of the planks varies from fair to poor. While almost all timbers include areas close to the plank's original surface, all surfaces are checked and eroded to some extent. Planks on the southern half of the hull fared better over the millennia than those on the northern half, where insect destruction and erosion destroyed about 60–80% of the planks' original volume. All timbers were fashioned in a similar manner from the same wood type, a non-coniferous species.[2] The hull's centerline runs along the center of B3, a plank with the finest grain and fewest knots. On the inner face of B3, the centerline bisects a 2.5 cm deep mortise with no outlet.

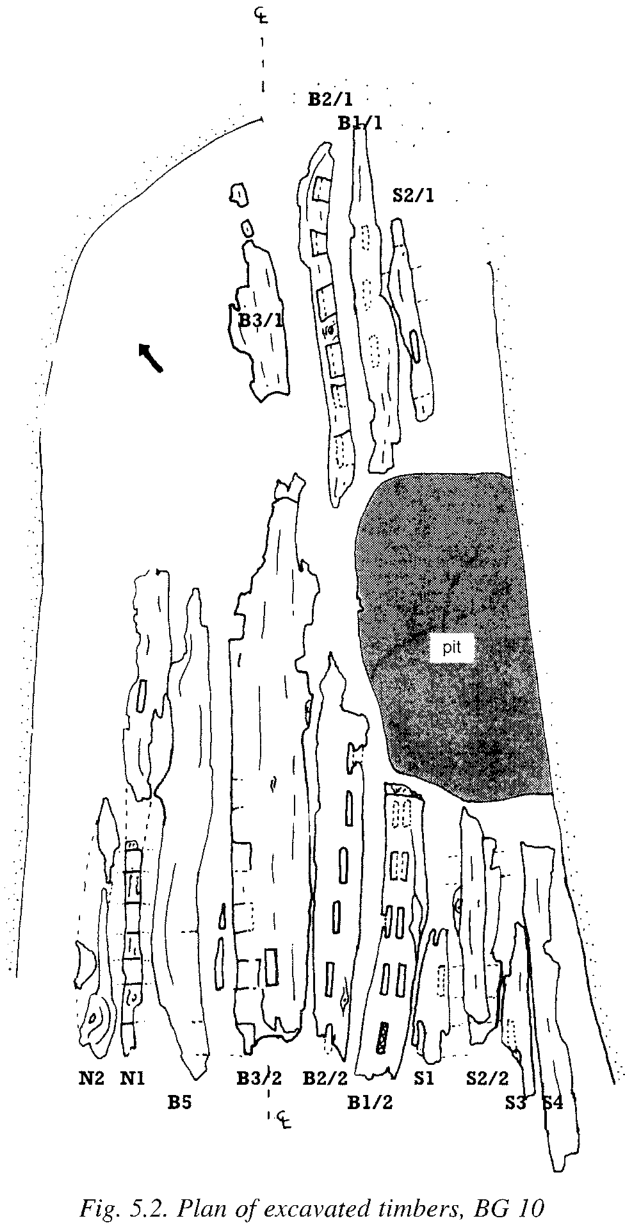

Fig. 5.2. Plan of excavated timbers, BG 10 (drawing: author).

PLANKS

The excavated area included five bottom strakes and six side strakes (two on the northwest side and four on the southeast side). Planks are labeled sequentially from south to north across the hull, and from the east towards the west. Some of the planks retain their original thickness of 6 cm, and other evidence demonstrates a constant planking thickness of 6 cm in both excavated and visible timbers (sheer plank outboard edges throughout the boat grave, for example). Best preserved areas are those near knots, and exuded resin is visible in a number of areas. The largest plank (B3/2) measured 1.7 m long (remaining) and had a maximum width of 19 cm.

Plank edges are straight, without joggles. As Fig. 5.2 illustrates, some are separated by gaps of up to 5 cm. The edges of these planks are present in most cases. Several planks (S3, S1) probably may be identified as the ends of drop strakes. There are no nibbed ends or joints in strakes. The first plank on each side is adjacent to and fitted to the pertinent bottom plank at an angle of about 140 degrees. The precise nature of the junction is unclear at present, but a subject of intense interest and study to be further explored with fragment models.

FASTENINGS

The boat in grave 10 at Abydos was sewn together through lashing channels that created transverse lines of reinforcement and strength in the hull. The lashing, preserved in two instances, consists of a woven strap about 7.5 cm wide. No wood-to-wood fastenings (mortise-and-tenon, treenail or pegs) were recorded.

Figure 5.3 illustrates the fastenings discussed here. The type of channel is dependent upon plank location in the

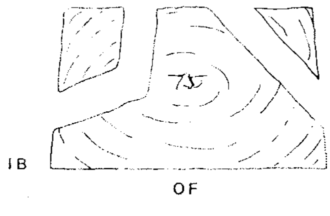

Fig. 5.3. Examples of lashing channels in B1, 6 cm thick (drawing: author).

hull. For example, the outboard edge of B1/2 includes lashing channels that angle from near the plank's centerline to either edge, terminating in a mortise with a center typically 2.5 cm above the plank's outer face. Angles are consistent at approximately 55–60 degrees from the inner face to an edge. The inboard edge of the same plank features L-shaped lashing channels, mirrored by L-shaped lashing channels on the outboard edge of B2/2. Neither the inboard edge of B2/2 nor the south edge of B3 has any fastenings. The north edge of B3 and the inboard edge of B5 have L-shaped lashing channels. At the extreme eastern end of the hull, L-shaped mortises (90 degrees) seem to be the primary fastening mechanism. Side planking was fastened through channels parallel to planking faces and passing completely through individual timbers and with lashing in L-shaped channels.

Whether the channel is angled, L-shaped, or parallel to the face, average mortise dimensions along the edges are 7–8 cm long and 1.7–2.0 cm thick (approximately one ancient Egyptian palm long and one digit thick). Five mortises on two timbers (B2/1 and N1) incorporate chisel blade cuts. The blade probably was metal and measured 2 cm long and about 4 mm thick. Closely spaced (0.6–1.0 mm) saw marks cover about 8 cm of B3's south edge. No other tool marks are visible on the timbers.

BATTENS, BUNDLES AND MATTING

Insect frass and decayed botanical matter filled gaps between planks at the time of excavation. Despite the degraded condition of much of the plant matter, it is clear that many of the plank edges did not originally touch each other, but were separated by a now-vanished intermediate material. Impressions in mud plaster below and long plant fibers within the gaps between planks document something other than a plank present at the time of burial. Research to identify the filling material continues. A separate layer of matting covered the interior of the hull, and there is some evidence for wood battens of the same species used to construct the boat.

DECORATION

Inside the hull, matting covered its dark, reddish-brown wood. The outer surface was coated in plaster and a solid dark yellow or ochre pigment, also seen on other boats. No other decoration was identified.

Analysis

Figure 5.4 provides a minimal interpretation of evidence for the original construction of the boat. The BG10 profile (Fig. 5.5) is reconstructed from overall measurements and from the rising angle of its eastern end. No determination of bow or stern can be made from available evidence. If a length of 22 m is assumed, with a load waterline of about 30 cm, displacement may be calculated at about 10 metric tons. The weight of the hull will depend upon the wood type used to build it, but it is likely to be at least 1.5 tons.

The flat-bottomed construction and angular chine allow a precise definition of the Abydos hull form, but several areas will benefit from further analysis. Separation or splaying of planks cannot account for the impressions in the mud plaster beneath the 4–5 cm gaps between bottom

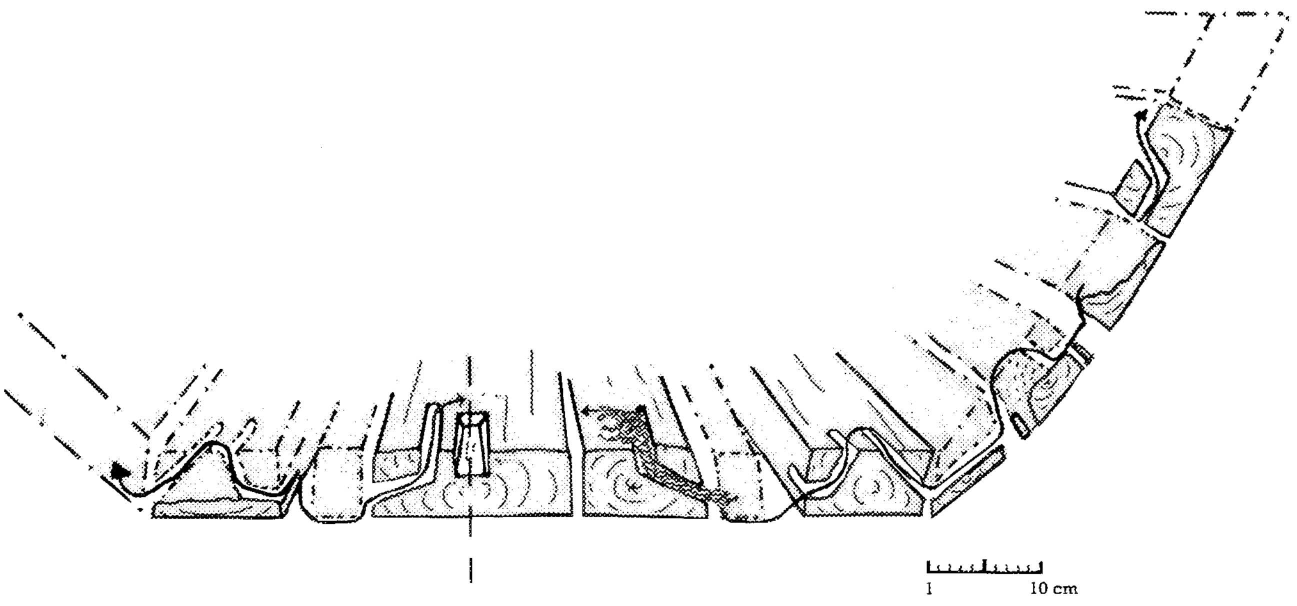

Fig. 5.4. BG 10 section, 2000. Extant planks are indicated by solid lines. This section is between 5 and 10 cm east of the boat's west end (drawing: author).

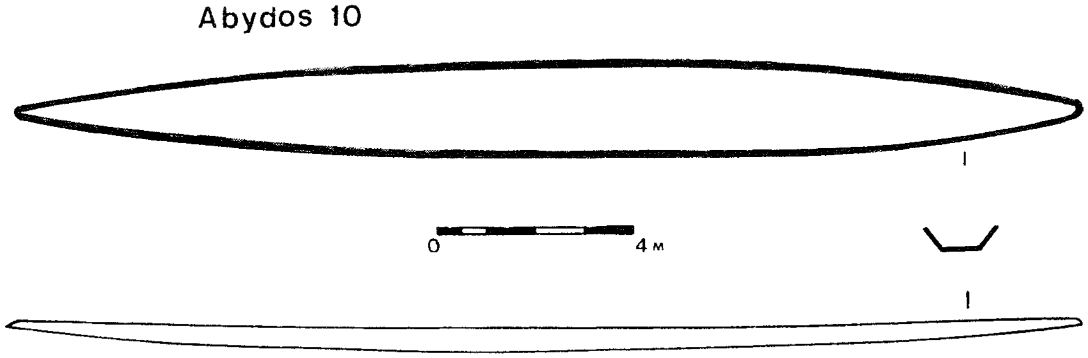

Fig. 5.5. BG 10 profile (drawing: author).

planks. Further study and excavation of an entire hull will clarify this issue.

Similarities with other ancient Egyptian hulls are numerous (see Ward, 2000, for details of other vessels). In the Dashur boats (*ca.* 1850 BCE), the central plank has the closest and cleanest grain. Lashing channel dimensions are paralleled by lashing channels in timbers from Lisht (*ca.* 1950 BCE). Remains of lashing within channels point to the same strap-like composition as that used to join Lisht timbers. Like the Khufu ships (*ca.* 2550 BCE), the timbers have virtually no tool marks remaining upon them. Hull proportions and shape below the waterline point to clear connections between Abydos and Khufu vessels. Like all the craft mentioned above, the lashing is transverse – across the hull, rather than along planking seams – unlike any other sewn boats in the world. And like all the other ancient Egyptian hulls of the pharaonic period, there are no fastenings that penetrate the hull planking – all connections are between plank edges and across the inner face.

Standardization is evident in edge mortises of very similar dimensions placed at the same distance from the hull's outer surface for both angled and L-shaped lashing channels. In addition, channels were cut at similar angles to the plank edge. Standardization is evident in the distribution of fastening types across the bottom, but not in plank shapes where symmetry does not seem to have played the same role it did in later vessels.

The construction of the Abydos boat argues against the interpretation of another group of First Dynasty timbers as belonging to ancient watercraft. Petrie suggested that timbers from Tarkhan had fastening patterns that allowed them to be reassembled into a niched façade similar to a *serekh* (Petrie *et al.*, 1913: pl. IX–X). All of the timbers, now on display in the Petrie Museum of University College, London, have mortises that pass perpendicularly through the planks. These features, combined with plank dimensions, argue against the Tarkhan planks being from watercraft (Ward, 2000: 32–38, *contra* Vinson, 1994: 18). Fastening methods are similar, but the mortises are about half the length of the Abydos examples and not truly comparable.

Conclusion

The presence of so many full-sized vessels in a monumental context is unprecedented in ancient Egypt. Several sites include five or six watercraft outside pyramids (Ward, 2000: 70), but only deposits of models provide such high numbers in later periods. The relationship of boats and funerary complexes offers the opportunity for speculation: if the non-cemetery portion of Abydos includes these boats, probably related to one of the nearby early First Dynasty monuments, then the boats are not specifically associated with the dead ruler's body. By the Fourth Dynasty, mortuary practice included the burial of three intact and two disassembled vessels around the pyramid and causeway of Khufu, who is presumed to have been interred deep within the pyramid. Continuing to investigate the Abydos hulls and their relationship to the funerary monuments will provide insights into the development of state religious practice.

The Abydos boats are the world's oldest planked hulls and are built in a previously undocumented manner, which this preliminary report begins to describe. Although they were buried in a strictly ceremonial context, their function cannot be determined. The long, slender hulls have precedents in the wooden vessels pictured on Naqada IIb pottery and antecedents in the flat-bottomed Khufu ships. The techniques used to build the boats reflect both their antiquity and practices used by Egyptian shipwrights for thousands of years after the desert covered these boat graves.

Acknowledgment

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Notes

1 Directions are given in accordance with local North.

2 Contrary to previous reports, the boats all seem to be built of the same wood, which has been identified as an indigenous species. Further scientific identification is planned, but not available at this writing.

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6. Towards the Determination of Mycenaean Shipbuilding Techniques, Tools and Materials

Dimitra Kamarinou

Introduction

Due to the lack of a Mycenaean shipwreck, the researcher who wants to investigate the question of Mycenaean shipbuilding techniques has to examine first: what were the Bronze Age shipbuilding techniques in the south-eastern Mediterranean and whether there are any indications that they were also used in Mycenaean shipbuilding.

The sources of information are mainly the archaeological finds of Bronze Age ships and Egyptian pictorial representations of shipbuilding processes.

The shell – first method occurs in all vessels. The earlier Egyptians (*Cheops* ships, *Dashur* boats) use the mortise and tenons joint combined with lashings and the later ones (*Ulu Burun*, *Cape Gelidonya* wrecks) the pegged mortise and tenons joint. The mortise and tenons joint technique is depicted as early as 2.500 BC in the Saqqara wall paintings.

The aim of this paper is to examine the evidence that is related to the above question within the historical context of the LHIIIC civilization and with respect to the evolution of ancient Greek shipbuilding.

Many scholars (for example, Mark, 1991; Casson, 1992) agree that the above techniques were familiar and widely used by the Mycenaeans. This position is initially justified by the following historical data: the Mycenaean civilization was influenced by and influenced its neighboring civilizations that flourished along the south-eastern Mediterranean coastline. It evolved through a two millennia history of civilizations mainly nautical (Cycladic, Minoan) and incorporated their experience in many fields. Its wealth was dependent on its very considerable nautical power. Given the importance of a strong and competitive navy for the existence of the Mycenaean civilization, it is logical to conclude that the Mycenaeans would at least know and adopt, if they had not introduced themselves, the essential innovations in the shipping technology of their time. This is a rational conclusion, whose reliability has to be further investigated through the study of the available archaeological data.

The close relationship of the Minoan and the Mycenaean civilizations to the south-eastern Mediterranean ones is well testified by the written evidence and by the data from excavations. In the nautical field there is much evidence for commercial exchanges (Cline, 1994). Even the difficulty of determining the origin of the excavated Late Bronze Age vessels shows these close interrelations.

We may examine whether the evolution of Mycenaean shipbuilding was chronologically parallel or similar to the one that occurred in nearby civilizations. At least the Egyptian example, for which there is enough evidence available, shows that this is the case (Landström, 1970; Casson, 1994). The evolution of Egyptian shipbuilding started from paddled vessels, at a time parallel to the Early Cycladic civilization and had reached by the end of the Bronze Age the essential innovations that are also to be seen in Mycenaean ship representations: a shorter and heavier hull, a straight stempost, a simple undecorated sloping stern, a short mast positioned amidship, a low and wide sail and, most important, the introduction of the keel and of the loose-footed brailsail.

We may also investigate whether there are any indications that the Mycenaean civilization had incorporated or developed the shipbuilding experience of its preceding, mainly nautical, civilizations. The study of the form of the LHIIIC ship representations (Kamarinou, in press), clearly shows their relationship and their evolution from the Early Cycladic (for example the form and the function of the stempost, the development of rowing from paddling), from the Minoan and the Theran (for example the type of sail and rigging, the high bow and stern) and the important innovations they introduced (for example, the loose footed sail with brails instead of the boom-footed sail of the Theran and the Minoan civilisations).

As the pictorial evidence shows, continuity in evolution and innovation in shipbuilding are clearly seen in the Geometric ships, which are very similar to those of the LHIIIC and reached their peak in the building of the trireme. It has to be emphasised that the introduction of the ram, only a few centuries later (probably in the Geometric ships and definitely in the trireme), that requires a very solid and demanding bow structure, is a revolutionary innovation: it differentiated the main concept of a war-ship and transformed it into a naval weapon as well. This would have been impossible without experimenting for centuries and profiting from the shipbuilding experience of earlier and contemporary civilizations.

In the Mediterranean only few wrecks have been fully excavated and for this reason we can hardly apply the laws of statistics and reach generalizations. But finds later than the *Ulu Burun* wreck show that the shell-first method and the mortise and tenons joint continued into Roman times, that vessels built with the mortise and tenons joint technique coexisted with pure laced ones and that both techniques were often combined in the same vessel at least untill late in Classical antiquity. Since there is evidence that both techniques were used before and after the Late Bronze Age, it is logical to conclude that they were also used by the Mycenaeans.

An important question is whether the Mycenaeans had the tools, the technological knowledge, the materials and even the social structure needed to apply these shipbuilding techniques, especially the use of the mortise and tenons joint.

Since Mycenaean shipbuilding tools have not been found in a wreck or in a shipyard, the question of the types of Mycenaean tools has to be answered through the following process: the tools used in the mortise and tenons joints construction were derived from the Egyptian shipbuilding depictions (Steffy, 1998:29–31). These are identical, according to their types, with the tools found in the *Ulu Burun* and the *Cape Gelidonya* wrecks (Bass, 1967; Pulak, 1993) and with the shipbuilding tools of the Homeric epic (Table 6.1). The tools described in the building of Odysseus' boat are the same as those shipbuilding tools that are described in other parts of the epic (Table 6.2). Given the fact that these are typical carpenter's tools as well (as it is also derived from the Homeric epic Table 6.2), E. Maragoudaki determined their form by comparing the finds from the above wrecks with those from the Mycenaean excavations (Blegen, 1937; Catling, 1964; Iakovidis, 1969;1980; Spyropoulos, 1972) (Table 6.3).

As for the materials used, we have no reason to doubt the validity of the detailed references in the Homeric epic for Mycenaean shipbuilding. They have been documented from many verses in the "Iliad" and the "Odyssey" (Table 6.4), they were available in Mycenaean times and were used in the Greek world in antiquity as written and archaeological evidence shows (Torr, 1894).

The social structure of the Mycenaean civilization, which is characterized by a high degree of specialization in labour and skills and a well organized society, could have permitted the application of sophisticated and demanding (in time and skills) methods of shipbuilding, such as mortise and tenons joints.

Tool	Homeric epic	Bronze Age Egyptian shipbuilding representations	Ulu Burun wreck	Cape wreck Gelidonya wreck
Axe	+	+	+	+
Adze	+	+	+	+
Chisel	+	+	+	+
Drill	+	?	+	
Plumb bob	+	+		
Hammering tool	+	+		+
Saw		+		

Table 6.1 The Bronze Age Mediterranean Shipbuilding Tools

Tool	Tools of Odysseus boat	Other references in the Homeric epic to shipbuilding tools	Carpentry tools in the Homeric epic
Πελεκυς (Axe)	ε234, ε244	Γ60–62, N391, 482–484, ι391	Δ485–486, N178–180, ψ114
Σκεπαρνος (Adze)	ε237, (ε245)	ι391, ε162–163	ψ196 (Φ44)
Τερετρον (Chisel and/or hand drill)	ε246		ψ198
Τρυπανον (Bow drill)		ι384–386	
Σταθμη (Plumb bob)	ε245	O 410	ψ197, φ43–44
Αρασσω (Hammering tool)	ε248		

Table 6.2. A comparative index of the references in shipbuilding and carpentry tools in the Homeric Epic

Shipbuilding tool	Mycenaean excavational finds	Tools in Linear B tablets
Axe	+	+
Adze	+	
Chisel	+	
Drill bit	+	
Plumb bob		
Hammering tool	+	
Saw	+	+

Table 6.3. A comparative index of the Bronze Age Mediterranean shipbuilding tools and the Mycenaean data.

According to nautical technology it has been shown that Mycenaean ships, as far as their form is concerned, have incorporated the innovations of their time. Additionally, recent geological research shows that there are indications of Mycenaean harbour installations in Pylos (Zangger *et al.*, 1997).

Finally there is evidence for the use of the mortise and tenons joints technique in the construction of houses and

Material	Subcategory of the material	Part of the ship used	References in the Homeric epic
Wood	fir	mast	ß 424, o 289
		oars	H 5, μ 172
	oak	hull	N 389–391, Π 482–484
	pine	hull	N 389–391, Π 482–484
	poplar	hull	N 389–391, Π 482–484, ε 241
	tar	surface of the vessel	30 references in black ships, tar: Δ 277
Leather		loops (oars)	δ 782
	ox	back halyard	μ 423
		brails	ß 426, o 291
Plants		ropes	Σ 553, Ψ 115
Colours:			
a. Red ("miltos" stone)		sides of the hull	τ 125, B 637
b. purple ("foiniki" shells)		sides of the hull	λ 124, ψ 271
c. blue		sides of the hull	γ 299, μ 100,148, O 693, Ψ 852,878

Table 6.4. Index of materials used in Homeric ships.

in carpentry from the Minoan and the Theran civilizations (Morgan, 1988:129). Does the Egyptian example show that the mortise and tenons joints technique was applied in carpentry as early as 3.000 B.C., but not in shipbuilding (Mark, 1996)? Does the fact that the earliest vessels we have found are lashed mean that this was the only technique used? On the *Cheops* ship (2.750 BC) and on the *Dashur* boats (1850 BC) there are mortise and tenon joints and some of the earliest known representations of shipbuilding (Saqqara wall paintings, about 2.500 BC) describe the process of the mortise and tenons joints technique (Steffy, 1998: 29–31). A ship is a more complex and demanding construction than a house or furniture, because it is difficult to meet simultaneously seaworthiness and safety standards. The result is that shipbuilding technology always had not only to incorporate known experience in wood technology, but also to lead the field in innovations. This fact is clearly stated in the Homeric epic (τ 125–130): if the Cyclops had had ships, they would have had the knowledge to build houses and not *vice versa*. Although the only known example of a Mycenaean artefact with mortise and tenon joints (a table from Mycenae: Muhly, 1996: 198–199, figs. 1–2) does not prove its use in shipbuilding, we can hardly exclude its application in a field that was the peak of their technology and also of vital importance to their existence.

Since there is not any reference in the Linear B texts to shipbuilding techniques, another question is, what is the evidence of the later texts which refer to Mycenaean shipbuilding. In the Homeric epic a description is given of the building process of Odysseus boat. The crucial point is that two different interpretations are based on the verses ε 247–249: Casson (1992) believes that this is a description of the mortise and tenons joints technique. The main argument against this interpretation is that there is not any reference to the stage of chiseling (either 'chisel' or a relevant verb). Instead, drilling («τετρηνεν») is mentioned, which, as Mark (1991:442) claims, is not absolutely necessary at the first stage of this technique, but is essential for the assembly of a laced boat. Since there is not any reference to a relevant tool, material or verb, he refers to two ancient Greek sources in order to interpret the word "αρμονια" as cord.

Although the use of lacing in shipbuilding is based on an important verse in the Homeric epic (B135), we believe that the interpretation of the above text as a description of the mortise and tenons joint technique is supported by the following three points: there is not any hint in the ancient Greek texts for the interpretation of the word "αρμονια" as cord. As Casson (1992:74) has well pointed out, in the sources that Mark (1991:443) cites to support his point, it means either 'sutural ligaments that connect the bones of a skull' or 'harmony'. The word "αρμονια" derives from the verb "αρμοζω"=fit well to each other and means in the ancient Greek texts of constructional context the joint between materials. In most of the texts «αρμονια» has a function similar to that of the mortise and tenons joints, or it means the seams (Diodorus Siculus, *Historiai*, 2.8; Pausanias, 2.25.9; Aristophanes, *Knights*, 532 etc.). In the unique shipbuilding text (Herodotus, 2.96), even if a lashing process is described, "αρμονιαι" cannot mean the cords. Even the word «δεσμος» (verb «δεω»), that characterizes Homeric vessels (ε33, 338, η234), in the ancient Greek texts, means anything used for tying and fastening and is not restricted to ligatures (even metal fastenings in the epic: Σ 379 and in the Linear B tablets). On the other hand in the epic there is a variety of nine different terms which clearly mean 'cords' (τ136,137 K443, ν100 Ψ115,854 Σ554 B135 δ782 ζ264 ß425,o290 μ51).

Finally, it is logical to assume that the verb that accompanies the means of joining the planks would be a characteristic one, which distinguishes the chosen technique from others. Hammering («αρασσεν») is the essential act for the mortise and tenons technique and not for lacing (even if it has an auxiliary role in the later technique in securing the strings with pegs (Mark, 1996: 46). The alternative verb «αρηρε» can fit in both cases.

The second point refers to the stage of drilling. The fact has to be considered that for the application of either technique it is essential to line up the holes or the mortises. This would be impossible or extremely difficult if all the holes or the mortises in all the planks were drilled first. This is also the case in lacing. The preserved laced vessels (for example, *Cheops* ship, *Bon Porté* wrecks) show that the planks are laced after they have been secured in their position with tenons or dowels. Thus drilling the necessary holes for the application of the lacing technique is a characteristic stage that is accomplished after fastening the planking together (with mortises or dowels, and after their final trimming. For this reason the Homeric description should not be considered as three subsequent stages that are applied to the whole of the planks after each stage is totally completed, but rather as a process that is continuously applied for the connection of each single plank to the hull.

The third point deals with the interpretation of the words "τερετρα" and "τετρηνεν". According to the Liddell Scott Lexikon the verb "τετραινω" means to open a hole and its derivative "τερετρα" is the means to accomplish this act. Although they are often translated in English as drilling, these terms are not necessarily restricted to drilling and could well mean the chisels and the stage of chiseling. This interpretation is reinforced by the fact that in the Homeric epic two different words are used, "τρυπανον" and "τρυπαω", which clearly mean the bow drill and the act of drilling holes (ι 384–385). Further study of ancient Greek texts proves that there are indeed two different basic tools, which are often mentioned together (*Anthologia Palatina*, 6.205, 6.103; Theodoretus, *Graecarum affectionum curatio*, 1, 101.4) and are also used in shipbuilding (Euripides, *Cyclops*, 460; Theodoretus 1, 101.4). Written at a time when the main shipbuilding technique was not lashing, the Theodoretus text mentions the most basic tools for shipbuilding (plumb bob, saw, adze, teretra, trypana) and that they are all used differently. The chisels, to which only the term «τερετρα» can correspond, could not be omitted, as they are essential tools.

Of course the question arises, whether the epic refers to Mycenaean or to Geometric ships. We have compared the references to ships in the Homeric epic with the LHIIIC and the Geometric ship representations. This study (Kamarinou, in press) has shown that the description of the ships in the epic, as far as it can be tested by the archaeological data, is compatible with the LHIIIC ship representations.

Conclusions

We, as an interdisciplinary team, intend to proceed further in this research and to experiment by building a Mycenaean 20/oared sailing ship using the type of pegged mortise and tenons joint that is evident in the *Ulu Burun* wreck. The aim of the construction is to combine up-to-date knowledge of Mycenaean ships with the methodology of experimental archaeology, in order to investigate further questions related to the functional necessity of the structural elements of a LHIIIC eikosoros, to the shipbuilding techniques, materials and tools and to the seaworthiness of the vessel.

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7. Mortise-and-Tenon Joints of Bronze Age Seagoing Ships

Cemal Pulak

Excavated off the southwestern coast of Turkey, the hull fragments from the Uluburun shipwreck represent the only remains of a seagoing hull from the Late Bronze Age Mediterranean. Based on artifact analysis and preliminary dendrochronological dating (Manning, 1999: 344–346; Pulak, 1999: 209, n. 2), it appears that the ship sank around 1300 B.C. The remains of its hull, while fragmentary, provide an invaluable glimpse into ship construction during the Bronze Age.

The artifact distribution suggests a length of about 15 m for the ship. The total capacity was at least 20 tons, based on the weight of the cargo, stone anchors, and ballast recovered (for overview of site, see Pulak, 1997; 1998). The Uluburun ship's primary cargo consisted of approximately 10 tons of copper ingots and a ton of tin ingots (Pulak, 2000). A total of 150 Canaanite jars, most filled with terebinth resin, and ten large storage jars (pithoi) containing pottery, pomegranates and probably also oil were other items recovered. Additionally, 24 anchors, weighing a total of 3.3 tons, were carried on the ship. Any estimates regarding dimensions and capacity of the ship are speculative, however, since it is not known how much of the original cargo perished.

The ship was built of cedar (*Cedrus* sp.) (Pulak, 1999: 212), a wood well-suited for shipbuilding, as it has minimal shrinkage and distortion when dried. It is easily worked, and is more resistant to decay in salt water than most other woods.

Three distinct sections of the Uluburun hull were preserved. The largest, most complete section measures 1.8 × 1.0 m and probably corresponds to an area slightly forward of midship. It includes a 1.7 m section of the keel, the complete widths of the port garboard and second strake, and a fragment of the third strake (Pulak, 1999: 215, 234, fig. 2). The interior surface of this section of planking was well preserved by sediment, but little original outboard surface remains. Surprisingly, there is no evidence of framing. Perhaps the frames or bulkheads were spaced more than 1.8 m apart, and none were present in this section. Alternatively, perhaps, this section is not wide enough to preserve evidence of their securing to the planking, if for example, they were not affixed to the first few strakes on either side of the keel. It is also possible that the Uluburun ship simply did not have any frames or similar lateral timbers, except perhaps, at the extremities of the hull, which did not survive.

Another unusual feature is the ship's keel. Unlike typical keels that project below the exterior surface of the planking, the Uluburun keel extends into the hull and sits 10 cm higher than the interior surface of the garboards. Moreover, the keel is wider (sided 28 cm) than it is high (molded 22 cm). It appears that the Uluburun ship had a rudimentary keel that was significantly more massive than a keel plank (which provides little longitudinal stiffening), but unlike a true keel in the modern sense.

The two remaining sections of hull were preserved under copper ingots and represent portions of the ship's starboard side. The ingots had been placed directly over the planking, using dunnage of branches and thorny brushwood (*Sarcopeterum spinosum*) to distribute some of the load. Although in poor condition, a flat scarf or, more likely, ADrop strake is preserved in the second section, indicating that it represents an area near the bow. The third section of hull contains a small part of the keel, with a sided dimension of only 21–22 cm. This indicates that the keel narrowed toward the bow and, presumably, also toward the stern.

The Uluburun hull was assembled with mortise-and-tenon joinery similar to that found much later on Greek and Roman ships. In contrast to the modern "frame-based" construction technique, wherein a ship's planking is fastened to a pre-erected skeletal framework, ancient builders used a "shell-based" method, which entailed edge-joining the planks with mortise-and-tenon joints locked in place with wooden pegs. Only then were frames added to the hull. Although there are examples of the use of pegged tenons in Egyptian woodworking since at least Dynasty I (*ca.* 3100–2890 BC) (Ward, 2000: 32), the Uluburun wreck provides the earliest example of pegged mortise-and-tenon joints in shipbuilding. Mortise-and-tenon joints had, of course, been used even earlier in Old Kingdom (*ca.* 2700–2180 BC) and Middle Kingdom ships in Egypt (Lipke, 1984: 64; Patch, Haldane, 1990: 34–35; Steffy, 1994: 25–27, 32–36; Ward, 2000: 52, 90–92, 114–115). These early Egyptian examples of mortise-and-tenon joints, however, were not locked with pegs. As far as we can determine, they were not utilized in shipbuilding, unless they were restricted to seagoing ships only, for which we have no surviving Egyptian examples. The unpegged mortise arrangement offered considerably less longitudinal support for the planking than did pegged joints. Their primary function was to align the planks during construction, which were then lashed together with ligatures.

The garboards on the Uluburun ship were fastened to the keel using mortise-and-tenon joints locked with oak pegs driven from the underside of the keel. The pegs in the garboards, as well as in all the other preserved mortise-and-tenon joints were driven from the interior of the hull. Tapered oak pegs averaging 2.2 cm in diameter at their inboard face were used.

The *Ulubrun* ship's mortise-and-tenon joints were more widely spaced and more robust than those of later Greek and Roman hulls of similar size (Pulak, 1999: 232, pl. 1). Unlike the mortise-and-tenon joints on most Greco-Roman hulls, however, those of the Uluburun ship were found to be extraordinarily deep. In fact, mortise-and-tenon joints in the Uluburun hull are about twice as long as those in Greco-Roman ships of comparable length. They are considerably longer than the optimal size for resisting shear stresses exerted on the joints. They are much more than simple plank fasteners and act as small internal "frames" that offered considerable lateral and longitudinal stiffening to the planking (Pulak, 1999: 220).

Pegged joints also occur in Near Eastern woodwork of the Middle Bronze IIB period (*ca.* 1800/1750–1650 BC), more than a millennium later than their first use in Egypt. When and where pegged mortise-and-tenon joints began to be used in shipbuilding is not known, but its earliest archaeologically documented use occurs in the remains of the Uluburun ship, which almost certainly was built somewhere along the Syro-Palestinian coast or on Cyprus. It is possible, therefore, that the practice of pegging mortise-and-tenon joints in shipbuilding developed on the Levantine coast and then spread westward from there (Basch, 1981; Wachsmann, 1998: 239–241). Moreover, the hull of the Cape Gelidonya shipwreck (*ca.* 1200 BC), another Late Bronze Age Syro-Palestinian or Cypriot ship, also seems to have been assembled with pegged mortise-and-tenon joints (Pulak, 1999: 214, 219–220).

The earliest archaeologically attested use of pegged mortise-and-tenon joinery in ships after the Bronze Age is seen in two mid 7th century BC shipwrecks at Mazarrón, Spain (Negueruela *et al.*, 1995: 195–196), but these sites are still under investigation and preliminary reports do not allow a full evaluation of constructional details. However, it is evident that the planks are joined with pegged mortise-and-tenon joints and that the widely spaced frames are lashed to the hull. Much more is known about the late 6th century BC shipwreck *Jules Verne 7* at Marseilles (Pomey, 1995: 475–480) and the late 5th century BC Ma'agan Michael shipwreck near Haifa (Steffy, 1994: 40–42).

The 4th century BC merchantman found off Kyrenia, Cyprus, however, is the most thoroughly documented and published example of an early ship built in this ancient fashion (Steffy, 1985; 1994: 42–59). Of the shipwrecks pre-dating the Kyrenia ship, in addition to the use of pegged mortise-and-tenon joints, lacing and lashing were also used in fastening of some timbers (frames to strakes in the case of the Mazarrón ship, and the ends of the lower strakes to the stem and sternpost on the *Jules Verne 7* and Ma'agan Michael ships). These ships, with their mixed mortise-and-tenon and laced construction may represent the amalgamation of mortise-and-tenon construction with another tradition.

The tenons of the Uluburun ship are made of oak, a much harder wood than cedar. The use of oak tenons in both the Uluburun and Cape Gelidonya hulls suggests that Late Bronze Age shipwrights knew the advantages of using tenons that were harder than the surrounding wood. It seems that the Uluburun ship relied heavily on the mechanical strength provided by long hardwood tenons, and that the use of such tenons supplemented the hull's lateral rigidity with an internal framework to compensate for the scarcity or absence of frames. Such construction may partly explain how heavy cargoes could be carried directly on the hull planking, using only dunnage to distribute the load over the planking without resorting to frames or bulkheads for lateral support.

One of the exposed Uluburun tenons is approximately 30 cm long, 6.2 cm wide, and 1.6 cm thick. Rather than alternating the mortise-and-tenon joints along one edge of a plank in relation to those along the opposite edge of the same plank, each mortise cut into a plank edge was positioned immediately adjacent to the nearest mortise cut into the opposite edge of the same plank, such that these mortises from opposite sides met edge to edge in the center of the plank (Fig. 7.1). On occasion, the edge of a tenon was cut into when the mortise along the opposite plank edge was cut. It is difficult to know whether this pattern was simply a convenient way of uniformly spacing the joints or if it represents an intentional structural practice. The latter seems likely, and the arrangement indeed suggests a conscious attempt to form "frames" consisting of paired tenons inside the planking that extend continuously up each side of the hull.

The removal of a substantial amount of wood to accommodate adjacent tenon pairs throughout a plank would seem to significantly compromise its structural integrity. In order to minimize this effect, it would seem that the joints should be evenly spaced, rather than paired immediately next to each other. This is why mortise-and-tenon joints are spaced evenly on later ships. I have argued elsewhere that adjoining mortises cut into opposing plank edges possibly created a stronger hull than did those spaced farther apart (Pulak, 1989: 221). This was one of the points investigated in the load tests described below, although results proved inconclusive.

In order to determine the strength of the mortise-and-tenon joints of the Uluburun hull and to compare them with those of typical Greco-Roman ships, full-scale sectional replicas of hull planking were assembled. Although studies investigating the loads acting on mortise-and-tenon joints have been previously undertaken (Morrison, Coates, 1986: 202–205; Morrison, 1996: 347–348), these limited studies involved the examination of only a few joints. There are no published empirical studies of the behavior of a series of mortise-and-tenon joints, nor are there any comparative data involving mortise-and-tenon joints of varying sizes and configurations. Therefore, in order to assess these issues and to arrive at absolute strength values for the mortise-and-tenon arrangements used in Bronze Age and Classical period ships, a total of four replicas for the Uluburun ship, and six for the Classical period ships (based on dimensions of the Kyrenia ship joints) were built for testing purposes. Two of the Uluburun replicas were built with paired mortise-and-tenon joints of the type used on the ship (Fig. 7.1), and two replicas were built with evenly spaced hypothetical joints (Fig. 7.2). Similarly, three Kyrenia replicas were built with evenly spaced mortise-and-tenon joints of the type used on the Kyrenia ship (Fig. 7.3), and three replicas had opposing hypothetical joints (Fig. 7.4). The purpose of building replicas with varying configurations was to compare the strengths of paired mortise-and-tenon joints with evenly spaced and opposing joints. Since during the load tests for all mortise-and-tenon configurations the central plank fractured longitudinally at its center, it became evident that the primary weakness was in the planks themselves rather than in the joints. Consequently, with regard to the strength of varying joint configurations, the tests proved inconclusive.

As noted above, the hull planking of the Uluburun ship was made of cedar (*Cedrus* sp.), while that of the Kyrenia ship was of Allepo pine (*Pinus halepensis*). For the purposes of this test, American southern yellow pine (*Pinus* sp.) was chosen, as its physical qualities approximate those of Aleppo pine (*P. halepensis*).

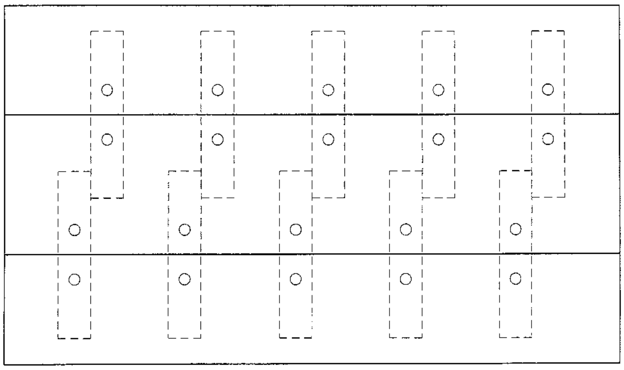

Fig. 7.1. Paired mortise-and-tenon joint of the Uluburun ship (length 116 cm).

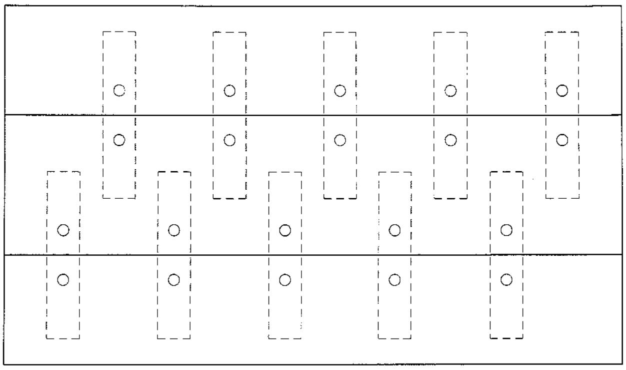

Fig. 7.2. Evenly spaced hypothetical mortise-and-tenon joints of Uluburun type (length 116 cm).

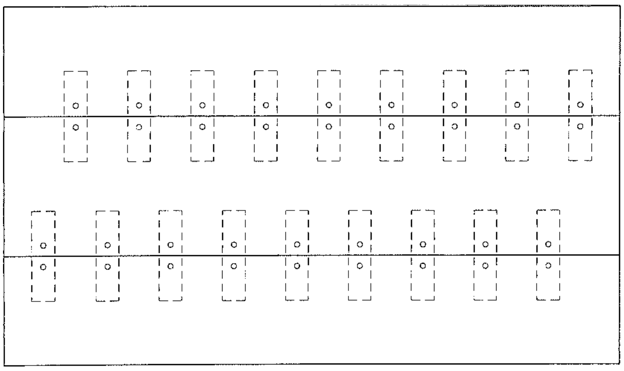

Fig. 7.3. Evenly spaced mortise-and-tenon joints of the Kyrenia ship (length 116 cm).

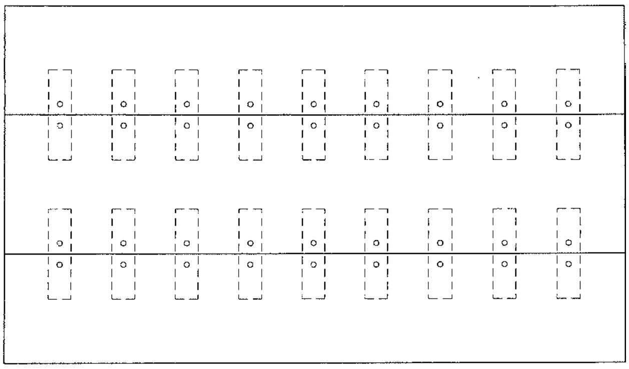

Fig. 7.4. Opposing hypothetical mortise-and-tenon joints of Kyrenia type (length 116 cm).

In order to obtain comparable test results for each hull type, a common length was chosen for the replica sections. Constructing the replicas using as a basis the same number of mortise-and-tenon joints for each of the two types would have been meaningless. The testing of such sections would have provided data only on the total number of mortise-and-tenon joints in each section, rather than for a common unit length of each type. The number of mortise-and-tenon joints in each of the two types of construction varies due to the differing sizes and spacing between the joints. This common length had to incorporate a reasonable number of mortise-and-tenon joints and be of a practical length for construction and testing purposes.

For replication purposes, three planks, each 116 cm long and 26 cm wide, were used for each section. This length was chosen as it would accommodate at least five mortise-and-tenon joints and because, in each of the two configurations, there would be about the same amount of uncut wood between the last mortise in the series and the long edge of the plank. The width of the plank roughly approximated the width of the second strake (26 cm) on the Uluburun ship and the comparable widest fifth (26.8 cm), sixth (26.7 cm), and eighth (26.5 cm) port strakes on the Kyrenia ship (Steffy, 1985: 79). When the combined width of the three planks proved too wide to fit between the support columns of the hydraulic loading apparatus, the outer two planks were reduced to 20 cm each, with the center plank retaining its original width of 26 cm. Although the actual average thickness of the Kyrenia planking was only 4 cm, its thickness was increased to 6.3 cm in order for the replicas to have the same thicknesses for the purposes of comparison.

Mortises were cut along either edge of the central plank, but only along the inner edge of the two outer planks. This labor-intensive task was greatly facilitated by the use of a power mortising tool with a special chisel-drill combination. However, the mortises of the Uluburun planking were too deep to be cut by this method alone and were completed by hand using mortising chisels. The mortises on the Uluburun planking were replicated as found on the original planking, as shown in Table 7.1 for both actual and experimental values. The center-to-center spacing between the mortises was averaged as 21 cm, the width of each mortise at 6.2 cm, its thickness at 1.7 cm, and its depth at 15.3 cm. For the Kyrenia ship, the center-to-center distance between the mortises was again based on the actual average value of 12 cm, with a width of 4.3 cm, and ADepth of 8.4 cm. Although the actual mortise thickness for the Kyrenia ship was only 0.6 cm, because the thickness of the planks was increased from 4 cm to 6.3 cm (an increase of 33%), the mortise thickness was also increased by 33% to 0.9 cm.

The tenons were cut from American Live Oak (*Quercus virginiana*), a species comparable to Mediterranean Turkey Oak (*Quercus cerris*), the wood probably used for making tenons in most eastern Mediterranean ships (Morrison and Coates, 1986: 204). After the tenon blanks were cut, all four edges on either shorter side of the tenon were chamfered at about 45 degrees. The Uluburun tenons measured 30 cm long, 6.1 cm wide, and 1.6 cm thick. The Kyrenia tenons measured 16 cm long, 4.3 cm wide, and 0.9 cm thick, the last dimension being 33% thicker than that of the actual tenon (Table 7.1). The smaller dimensions of the Kyrenia tenons allowed closer tolerances between tenons and mortises. These tenons were cut to almost the same dimensions as the mortises and could still be driven in with moderate ease. The much larger Uluburun tenons, on the other hand, easily became seized in the mortises and had to be cut narrower and thinner by at least 0.1 cm. to facilitate their insertion. Mortises of both ships were cut a little deeper than their tenon lengths (Table 7.1).

Once the planks had been assembled using the mortises and tenons, they were clamped tight and holes were drilled through the tenons for the placement of oak pegs. Standard commercial oak dowels were cut to size before being hammered in place. Peg diameters were based on actual average values for each ship. In both ships tapered oak pegs were driven from the inboard surface of the planking, with the wider end of the peg inboard. Since commercial oak dowels of constant diameter were used in the replicas, the widest diameter of the original pegs was used. For the Uluburun replica, pegs of 2.1 cm diameter were driven through the tenons, while pegs of 1 cm were used for the Kyrenia replica. As in the actual hull remains, the pegs were positioned directly at the center of each tenon at 4.6 cm from the plank seam in the case of the Uluburun replica, and 2 cm from the plank seam in the Kyrenia replica.

The completed sections were then subjected to load tests at Texas A&M University's Testing, Machining and Repair Facility of the Engineering Experiment Station. The replica sections were tested for compression and shear

	Length (cm)	**Width (cm)**	**Thickness (cm)**
Tenon, Uluburun	30	6.1	1.6
Tenon, Kyrenia (original)	16	4.3	0.6
Tenon, Kyrenia (experiment)	16	4.3	0.9
Mortise, Uluburun	15.3	6.2	1.7
Mortise, Kyrenia (original)	8.4	4.3	0.6
Mortise, Kyrenia (experiment)	8.4	4.3	0.9
Plank, central (Uluburun and Kyrenia)	117	26	6.3
Plank, side (Uluburun and Kyrenia)	117	20	6.3
Plank, Kyrenia (original)	–	–	4
Peg diameter, Uluburun	2.1	–	–
Peg diameter, Kyrenia (original)	0.6–1	–	–
Peg diameter, Kyrenia (experiment)	1	–	–
Peg spacing, Uluburun	21	–	–
Peg spacing, Kyrenia	12	–	–
Peg distance from plank seam, Uluburun	4.6	–	–
Peg distance from plank seam, Kyrenia	2	–	–

Table 7.1. Actual and experimental values used for Uluburun and Kyrenia planking, mortises, tenons, and pegs.

loads with hydraulic actuators and results were plotted against time.

The compression test set up consisted of 5-cm-wide steel supports (railroad tracks) spaced 51 cm apart, placed under the full length of each outer plank. A 5-cm-wide beam was brought to bear on the center of the central plank along its full length. Although such a severe loading situation in unlikely to occur under real-life sailing conditions, the purpose of the experiment was to obtain absolute load values under identical conditions in order to evaluate the relative strength of each construction method.

The two Uluburun replicas reached their fracture strengths at loads of 5,590 and 5,460 pounds, yielding an average value of 5,525 pounds (A and B in Fig. 7.5). The three Kyrenia replicas, loaded exactly in the same way, reached their fracture strengths at 3,580, 4,360, and 4,140 pounds, yielding an average value of 4,027 pounds (C, D, E in Fig. 7.5). This indicates that the Uluburun replicas are about 37% stronger than comparable Kyrenia replicas. It must be remembered that the Kyrenia replica involved 33% thicker planks and tenons than did the original ship. Although we do not know what the strength of the actual Kyrenia planking would have been, clearly it would have been significantly lower than the average value obtained for the more robust versions employed here.

One of each of the Uluburun and Kyrenia replicas were also subjected to shear loading. The replicas were mounted in a vertical position in the loading apparatus, supported as before with 5-cm-wide steel bars under each outer plank. The load was applied to the middle of the central plank, through a 5 cm-wide beam mounted under a 10 cm-wide beam. The Uluburun section reached its fracture strength at 50,000 pounds (A in Fig. 7.6), while the Kyrenia replica required only 30,600 pounds (B in Fig. 7.6). These tests reveal that the Uluburun replica was 63% stronger than the comparable Kyrenia replica. The first peak on the Kyrenia load diagram indicates the point at which the 5-cm-wide loading surface began sinking into the wood. After it had been completely pushed into the wood, the second beam (10 cm wide) came into contact with the wood. As it began spreading the load over a wider surface of the wood, the load was again transmitted to the mortise-and-tenon joints until the fracture strength was reached at 30,600 pounds on the second peak. Again, had the replica employed the thinner dimensions of the actual planking and tenons of the Kyrenia ship, the fracture strength would have been considerably lower.

Discussion and Conclusion

Tenons undoubtedly served to align the planking during hull assembly in shell-based construction. The large and unusually long tenons of the Uluburun ship must have

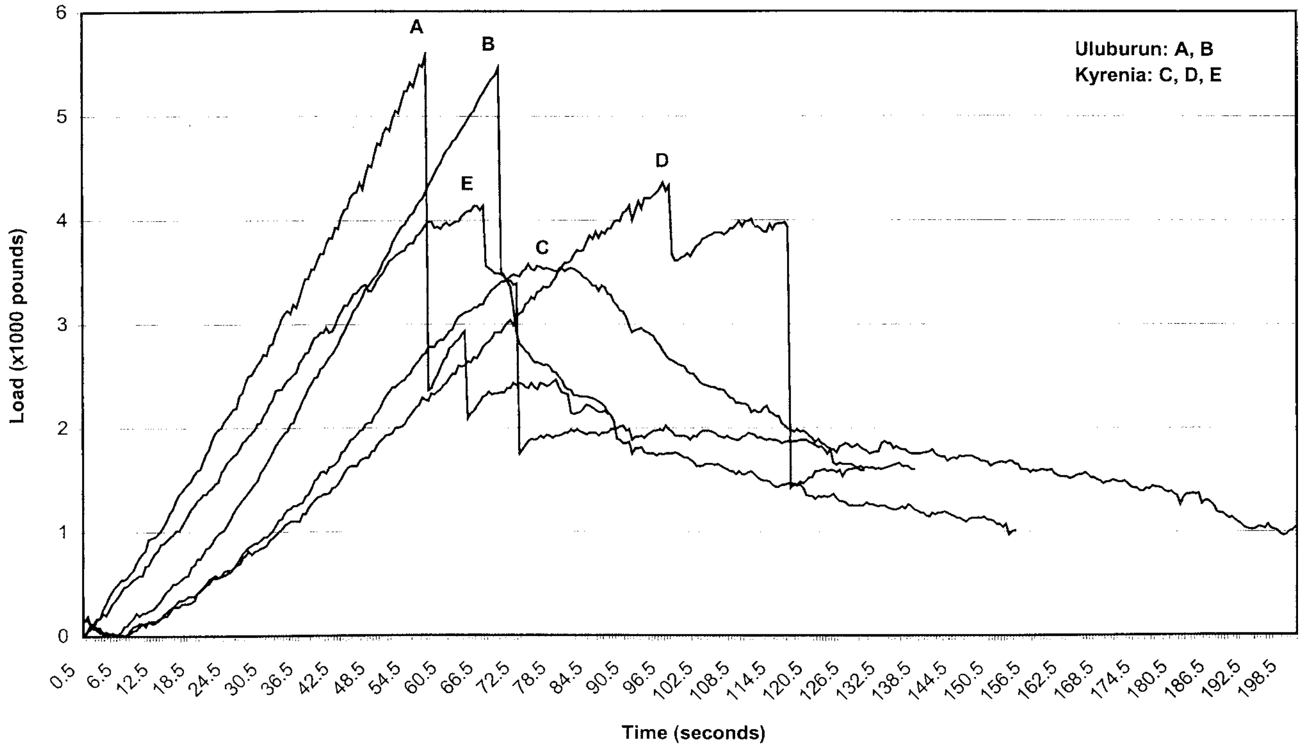

Fig. 7.5. Compression tests for Uluburun and Kyrenia planking replicas.

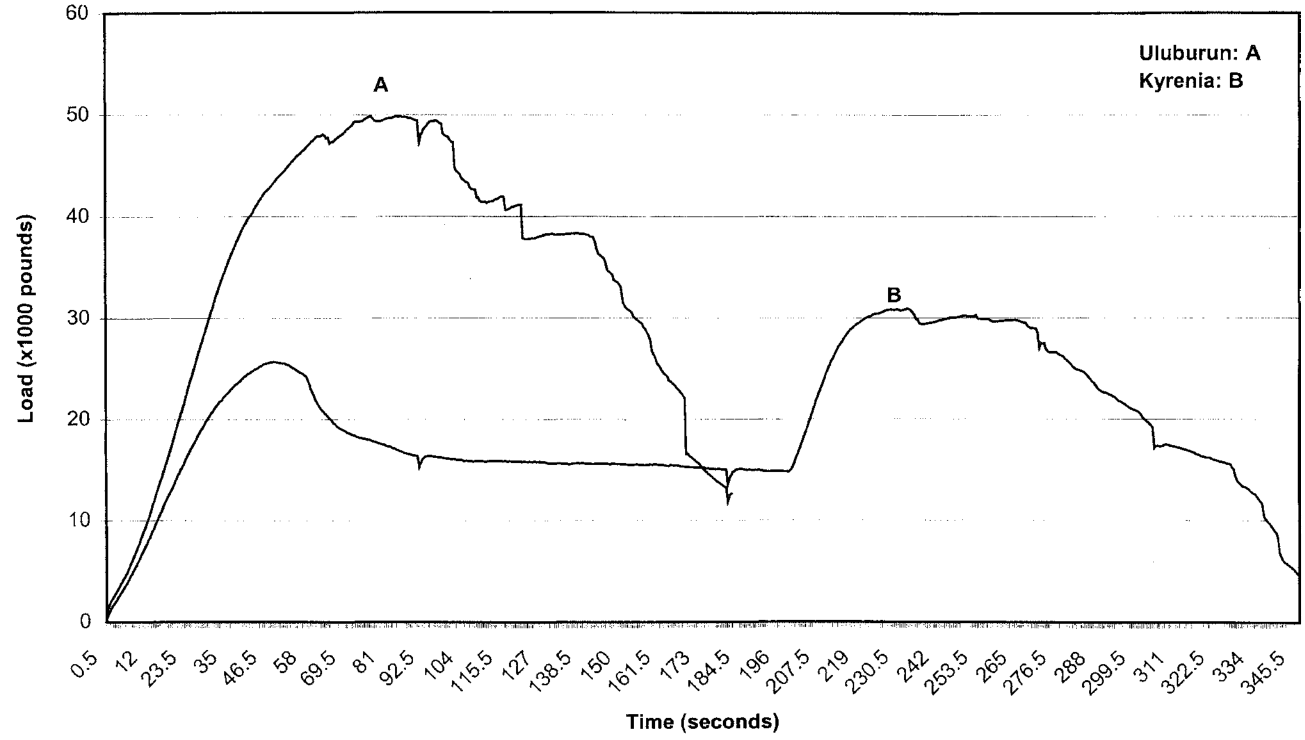

Fig. 7.6. Shear test for Uluburun and Kyrenia planking replicas.

also provided significant lateral stiffening and served as intra-plank frames. When the hull planks of a vessel are subjected to loads resulting from waves, wind, and the weight of the cargo, these forces would have been resisted by the hard oak tenons, which, in turn, distributed these stresses over the surrounding planks.

The large size of the Uluburun tenons necessitated wider spacing between the mortise-and-tenon joints than on Greco-Roman ships of comparable size. They are spaced nearly twice as far apart as on comparable vessels, such as the Kyrenia ship. Moreover, the configuration of the mortises and tenons of the Kyrenia ship differs from that of the Uluburun ship (Fig. 7.1) in that the mortises cut into one edge of a plank alternate regularly with those along the opposite edge of the same plank (Fig. 7.3). The length, width, and thickness of the Uluburun mortises and tenons are significantly larger than those of the Kyrenia ship.

The results of compression and shear-load tests on sectional replicas of the Uluburun ship and a modified version of the Kyrenia ship indicate that the Uluburun mortise-and-tenon joints are 37% and 63% stronger per unit length (116 cm), respectively, than the joints used on the Kyrenia ship. These values would be significantly higher if the actual plank and tenon thicknesses of the Kyrenia ship had been used.

The mortise-and-tenon joints of the Uluburun hull also alternate on opposite edges of the planks, but most of the joints are adjacent to each other, with the result that the mortises butt against each other at the center of the plank (Fig. 7.1). The effective wood area between pairs of mortise-and-tenons must be extended for the greater stresses exerted on the planking by the large, paired tenons, and to compensate for the weakness resulting from hollowing out so much of the plank to form these huge, paired mortises.

In the comparable unit lengths of each hull replica, there are 10 mortise-and-tenon joints in the Uluburun configuration, and 18 in the Kyrenia configuration. In compression loads, therefore, each Uluburun tenon could resist a maximum of 553 pounds, whereas the Kyrenia tenons could resist 224 pounds each. In shear loads, the Uluburun tenons could carry 5,000 pounds and the Kyrenia tenons only 1,700 pounds. It seems, therefore, that each Uluburun mortise-and-tenon joint is 2.5 times stronger in compression loads and nearly 3 times stronger in shear than the joints of the Kyrenia ship.

This should not be taken to mean that the Uluburun ship was built much more sturdily or that its structural integrity was 2.5 to 3 times as strong compared to a ship built in later Greco-Roman tradition. To the contrary, these results merely demonstrate that the mortise-and-tenon joints, and therefore the hull planking, of the Late Bronze Age Uluburun ship were several times stronger than those of the hulls of later shell-based ships. It does not indicate that the latter ships were constructed more lightly, however. The results of these tests may be taken to indicate that Greco-Roman ships relied much more heavily on framing for their integrity than their Bronze Age counterparts. In later periods, as shipbuilders began to rely more on a sturdier framework to maintain lateral rigidity of the hull (although installed after the hull had been completed with edge-joined planks), the use of long tenons and thick planks was no longer as crucial. Consequently, shorter and thinner tenons could be used, and the thickness of planks could be decreased. However, decreasing a plank's thickness increased its flexibility, which in turn compromised the watertightness of a hull. This factor, in turn, required the placement of mortise-and-tenon joints at closer intervals than those needed with thicker planks. Nevertheless, the use of thinner planking and a greater reliance on framing simplified the construction process and permitted greater control over the building of more complex and efficient hull forms. Therefore, one may see here the progression toward the placement of emphasis on the framework for strength that finds its ultimate expression mostly in the 11th century AD when a hull was conceptualized as a framework made watertight by the addition of planking, rather than as a watertight shell reinforced with beams, throughbeams, bulkheads, and frames.

Acknowledgment

The Uluburun shipwreck was excavated by the Institute of Nautical Archaeology (INA) at Texas A&M University between 1984 and 1994. The conservation of the artifacts continues in the Bodrum Museum in Turkey with funding from the Institute for Aegean Prehistory and the INA Board of Directors. The support of Texas A&M University allows me to spend three months each summer in Bodrum to direct the conservation and study of the artifacts. I am profoundly grateful to these institutions for their generous support over the years, without which much of nearly 20 tons of objects recovered from the site would still be in holding tanks awaiting cleaning and conservation.

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8. Timber Supply and Ancient Naval Architecture

Frédéric Guibal, Patrice Pomey

Introduction

The richness of ancient archaeological heritage provided by the shipwrecks located along the French Mediterranean seashore is of high interest for ancient maritime, economical and naval history studies. As an archaeological material, hull timber is most valuable in order to precise shipbuilding techniques; in addition to that, it also deserves to be analysed as a material resulting from tree growth, supplying information from its macroscopic shape to anatomical details. Indeed, morphological and anatomical characteristics of wooden elements may be helpful in ship construction studies in so far as it can precise timber use in naval architecture from tree selection according to architectural elements until their positioning (Rival, 1991: 324).

Capable of providing very accurate chronological information by means of dendrochronological analysis of ring-width series (Farrell, Baillie, 1976; Baillie, 1982; Schweingruber, 1993; Lambert, 1998), timber studies may also reveal on anatomical basis which tree species were used in ancient ship building for all architectural elements and how they were processed.

In order to answer these questions and to build up a master chronologies network for dating ring-width series in the Mediterranean area, a research project called «*Dendrochronology and Dendromorphology of Ancient Mediterranean shipwrecks*» has been launched since 1991 by *Centre Camille Jullian* (CNRS – Université de Provence), *Laboratoire de Chrono-Ecologie* (CNRS – Université de Franche-Comté) and since 1994 *Institut Méditerranéen d'Ecologie et de Paléoécologie* (CNRS – Université d'Aix-Marseille III) with the help of Département des Recherches Archéologiques Subaquatiques et Sous-Marines and the French Ministry of Culture. Wood sampling is based on well-known shipwrecks which are chosen according to geographical, archaeological and chronological criterions. That involves : (i) geographical areas where several wrecks are reported ; (ii) shipwrecks which are known to provide representative valuable wooden remains ; (iii) and for which probability is high to obtain good correlation between site ring-width chronologies (Baillie, 1982; 1995).

So far, eight fieldwork campaigns have been carried out from 1991 to 1999. Twenty-seven shipwrecks have been sampled in six geographical areas (Fig. 8.1): Gulf of Fos, Bay of Marseilles, Hyères islands, western Maures coast, Esterel coast, Bay of Cannes (Guibal, Pomey, 1998a; 1998b; 1998c; 1999).

Chrétienne A and *Chrétienne C* wrecks were analysed by S. Wicha (1997). *Dramont A* and *Dramont C* wrecks were analysed by Ch. Dagneau (*unpublished*). This paper will address only results of wood anatomy identification obtained in that project. Observations are carried out by means of binocular microscope on thin wood slices obtained manually according to transverse, radial and tangential plans. Twenty-four tree species representative of three biogeographical units have been identified.

In terms of present geographical distribution, out of twenty-four species, seven species are located at low elevation in the Mediterranean vegetation stage and therefore are often present near the seashore : Aleppo pine, umbrella pine, maritime pine, olive tree, oak, evergreen oak, chestnut. Eleven species are characterised by a wide geographical distribution, from mediotemperate Europe to low elevation Mediterranean areas restricted to river edges : alder, ash, beech, cornel tree, elm, hornbeam, lime, maple, poplar, walnut, willow. Six species are conifer trees from montane and subalpine vegetation stages : Scots pine, Bosnian pine, black pine, fir, spruce, larch.

The number of species varies according to the wreck: within a same shipwreck, variation of species frequency is such than some species may be dominant while others may be poorly represented, for instance only by joinery elements. Therefore, species distribution will be described according to architectural structural elements.

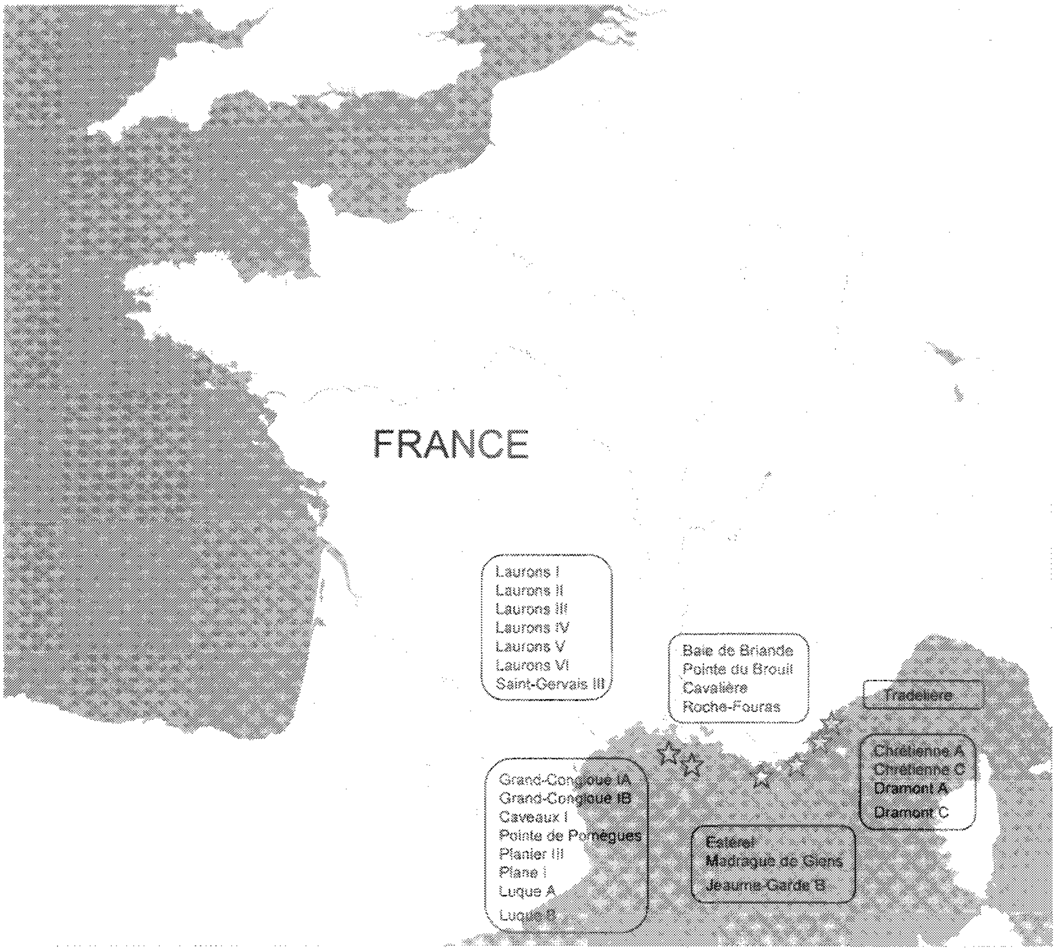

FRANCE
Laurons I
Laurons II
Laurons III
Laurons IV
Laurons V
Laurons VI
Saint-Gervais III
Baie de Briande
Pointe du Brouil
Cavalière
Roche-Fouras
Tradelière
Chrétienne A
Chrétienne C
Dramont A
Dramont C
Grand-Congloue IA
Grand-Congloue IB
Caveaux I
Pointe de Pomègues
Planier III
Plane I
Luque A
Luque B
Estérel
Madrague de Giens
Jeaume-Garde B

Fig. 8.1. Localisation of shipwrecks.

Axial elements (Fig. 8.2)

A preferential use of three sorts of species appears clearly:

- broadleaved species with high resistance quality: evergreen oak (*Pointe du Brouil, Dramont C*), oak and elm (*Madrague de Giens, Pointe de Pomègues, Laurons 1* and *2*) and also hornbeam (*Chrétienne C*) or beech (*Chrétienne A*);
- mountain conifer species: larch (*Pointe de la Luque B*), Bosnian pine (*Cavalière*) and Scots pine (*Chrétienne A, Tradelière*);
- species whose availability is large as Aleppo pine (*Cap de l'Estérel, Saint-Gervais III, Laurons 2*).

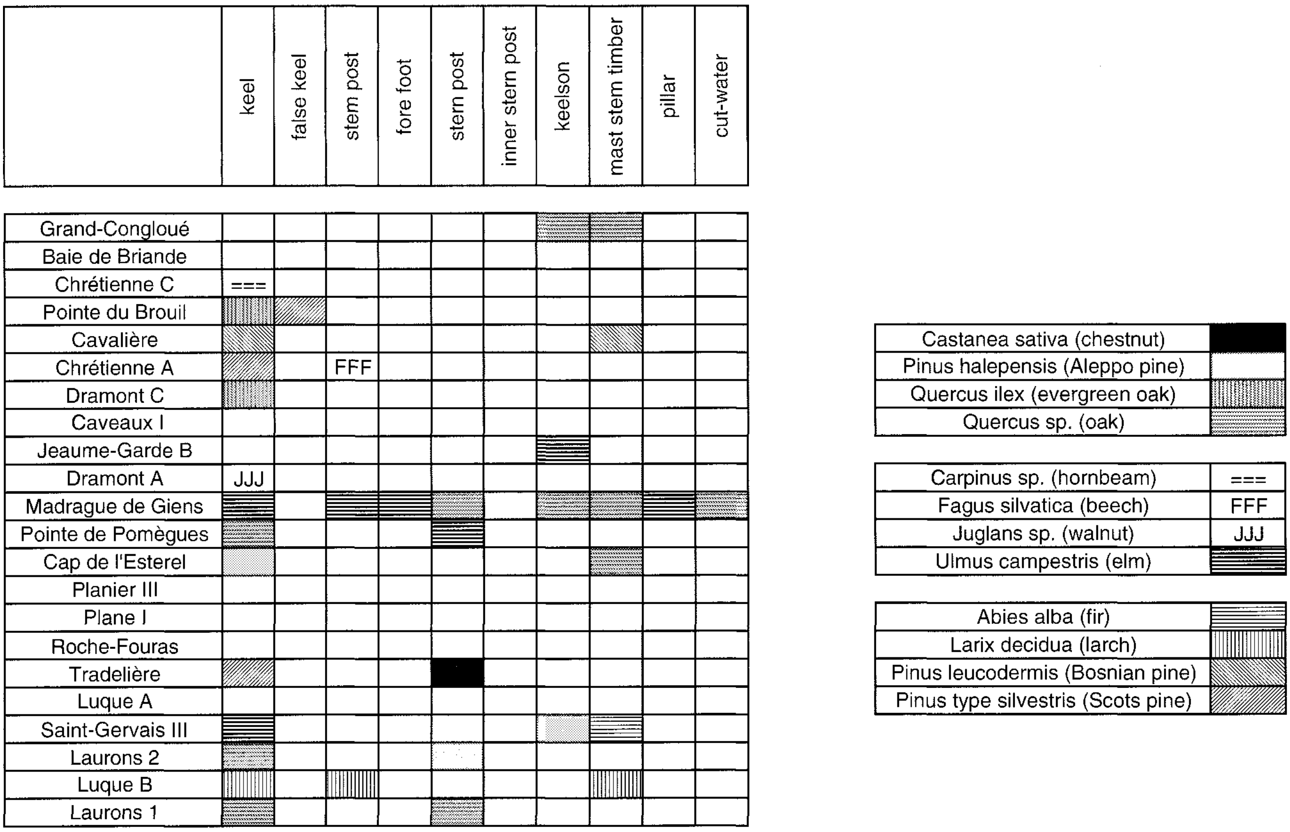
Apart this latter species which is easily available near seashore, species seem to have been selected for their mechanical quality and their durableness. It must be stressed also that highly-resistant species as oak, larch or Bosnian pine were used for mast stem timber. Only that from *Saint-Gervais III* for which fir was used goes against that and could reveal difficulties in timber supply.

Planking (Fig. 8.3)

Conifer species are largely used probably due to their elasticity which makes them flexible enough to be shaped according to shell first processes as usual in ancient Mediterranean (Pomey, 1998). On one side, mountain conifer species as larch and Scots pine are probably used for their durableness and also for their capacity to withstand shocks and compression. On the other side, Aleppo pine, due to its large availability in coastal areas is largely used.

Ten wrecks (*Baie de Briande, Chrétienne C, Dramont C, Caveaux I, Cap de l'Estérel, Planier III, Plane I, Roche-Fouras, Tradelière, Pointe de la Luque A and B*) exhibit a high homogeneity, as only one species was used for planking: fir, larch, Aleppo pine, Scots pine, Bosnian pine, Black pine.

Seven wrecks (*Pointe du Brouil, Cavalière, Jeaume-Garde B, Pointe de Pomègues, Saint-Gervais III, Laurons 1*) are also rather homogeneous as two tree species are associated within planking (larch and Aleppo pine; Scots pine and Aleppo pine or Black pine or Bosnian pine or fir).



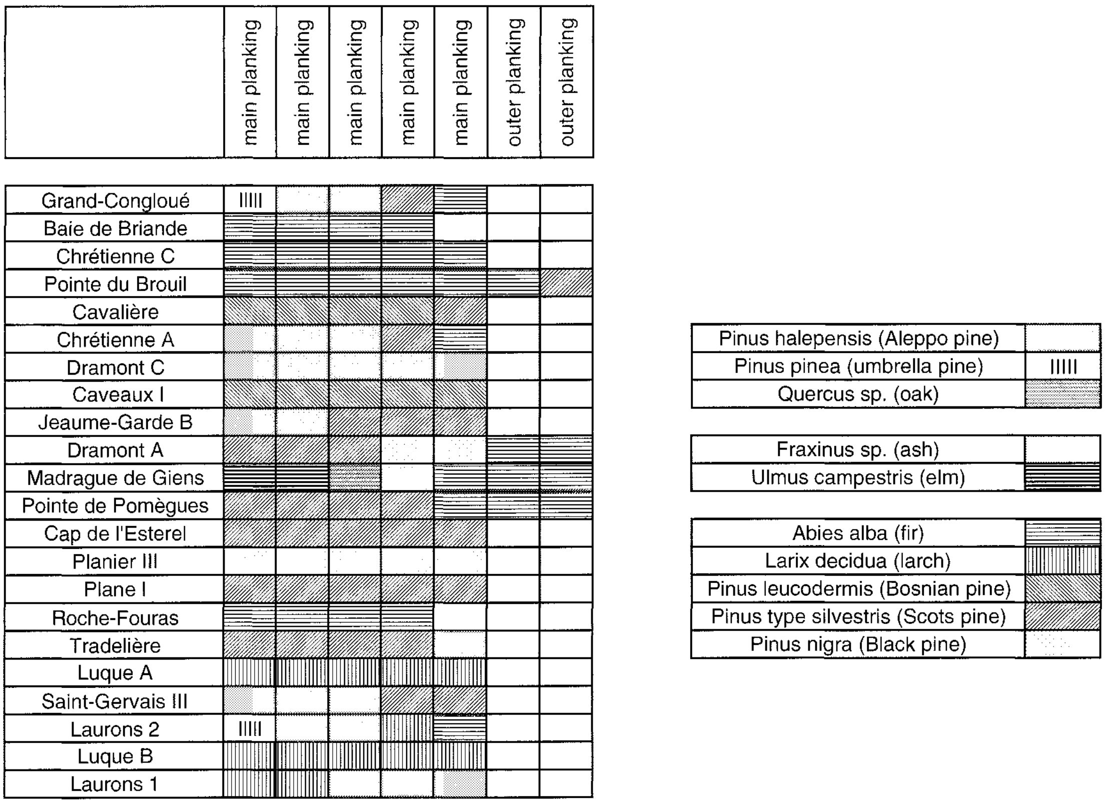
	keel	false keel	stem post	fore foot	stern post	inner stern post	keelson	mast stem timber	pillar	cut-water
Grand-Congloué							▒	▒		
Baie de Briande										
Chrétienne C	===									
Pointe du Brouil	▦	▨								
Cavalière	▧							▧		
Chrétienne A	▨		FFF							
Dramont C	▦									
Caveaux I										
Jeaume-Garde B							▤			
Dramont A	JJJ									
Madrague de Giens	▤		▤	▤	▒		▒	▒	▤	▒
Pointe de Pomègues	▒				▤					
Cap de l'Esterel	▒							▒		
Planier III										
Plane I										
Roche-Fouras										
Tradelière	▨				■					
Luque A										
Saint-Gervais III	▤						▒	☰		
Laurons 2	▒				░					
Luque B	▥		▥					▥		
Laurons 1	▒				▒					

Castanea sativa (chestnut)	■
Pinus halepensis (Aleppo pine)	
Quercus ilex (evergreen oak)	▦
Quercus sp. (oak)	▒

Carpinus sp. (hornbeam)	===
Fagus silvatica (beech)	FFF
Juglans sp. (walnut)	JJJ
Ulmus campestris (elm)	▤

Abies alba (fir)	☰
Larix decidua (larch)	▥
Pinus leucodermis (Bosnian pine)	▧
Pinus type silvestris (Scots pine)	▨

Fig. 8.2. Identified tree species according to structural element (axial) and wreck.



	main planking	main planking	main planking	main planking	main planking	outer planking	outer planking
Grand-Congloué	IIIII	░		▨	☰		
Baie de Briande	☰	☰	☰	☰			
Chrétienne C	☰	☰	☰	☰	☰		
Pointe du Brouil	☰	☰	☰	☰	☰	☰	▨
Cavalière	▧	▧	▧	▧	▨		
Chrétienne A	▒	░	░	▨	☰		
Dramont C	▒	░	░	░	▒		
Caveaux I	▧	▧	▧	▧	▧		
Jeaume-Garde B	▒	░	▨	▨	▨		
Dramont A	▨	▨	▨	░	░	☰	☰
Madrague de Giens	▤	▤	▒		☰	☰	☰
Pointe de Pomègues	▨	▨	▨	▨	☰	☰	☰
Cap de l'Esterel	▨	▨	▨	▨	▨		
Planier III	░	░	░	░	░		
Plane I	▨	▨	▨	▨	▨		
Roche-Fouras	☰	☰	☰	☰			
Tradelière	▨	▨	▨	▨			
Luque A	▥	▥	▥	▥	▥		
Saint-Gervais III	▒			▨	▨		
Laurons 2	IIIII			▥	☰		
Luque B	▥	▥	▥	▥	▥		
Laurons 1	▥	▥			▒		

Pinus halepensis (Aleppo pine)	
Pinus pinea (umbrella pine)	IIIII
Quercus sp. (oak)	▒

Fraxinus sp. (ash)	
Ulmus campestris (elm)	▤

Abies alba (fir)	☰
Larix decidua (larch)	▥
Pinus leucodermis (Bosnian pine)	▧
Pinus type silvestris (Scots pine)	▨
Pinus nigra (Black pine)	░

Fig. 8.3. Identified tree species according to structural element (strakes) and wreck.

The wrecks *Dramont A* and *Laurons 2* which respectively associate three (Scots pine, Black pine, fir) and four (Aleppo pine, umbrella pine, fir, larch) tree species are quite heterogeneous.

In addition to that, *Madrague de Giens* shows a main planking made of elm with Black pine and fir only appearing in repairs which reveals a high care in the building of this ship, as an outer planking confirms that. This outer planking as this at *Pointe de Pomègues* and *Dramont A* is made of fir, a lightweight wood, flexible enough for that use.

Frames (Fig. 8.4)

Unlike planking, tree species used for frames are quite varied. Homogeneity is noticeable at only five wrecks as only one species was identified: *Chrétienne A* and *Pointe de Pomègues* (oak), *Pointe de la Luque A* et *B* (larch), *Cavalière* (Bosnian pine).

Six wrecks also have a rather homogeneous frame as two or three species were used : *Baie de Briande* (oak, maple with a single element), *Dramont C* (oak, evergreen oak), *Caveaux I* (oak, elm), *Jeaume-Garde B* (elm, Aleppo pine), *Dramont A* (oak, evergreen oak), *Plane I* (alder, poplar), *Cap de l'Estérel* (oak, evergreen oak, walnut), *Roche-Fouras* (oak, elm, willow, – with a single element).

That is not the case with the seven wrecks left of which six (*Chrétienne C*, *Madrague de Giens*, *Planier III*, *Tradelière*, *Laurons 2*, *Laurons 1*) show four or five species while *Saint-Gervais III* display ten species used!

The last two groups include both hardwoods with good mechanical properties (oak, elm), easily available species and mediocre species (alder, poplar) whose only interest is their low weight, their availability and as far as alder is concerned, a fairly good stability in humid conditions. Most often, availability matter seems to prevail : that is the case at *Chrétienne C* which shows a large use of hornbeam, which is one of the densest hardwoods but not stable under conditions of changing humidity.

Longitudinal elements (Fig. 8.5)

Wales are generally made of the same species than the planks (spruce, larch, elm). Same thing appears for stringers and ceiling planks which are made of the same species than the planks apart *Chrétienne C* for which stringers are made of beech, hornbeam and oak or *Madrague de Giens* for which they are made of oak, Black pine, Scots pine and elm.

Joinery (Fig. 8.6)

These elements are made of hardwoods, preferentially evergreen oak. But conifer species are also identified, as fir used for treenails (*Baie de Briande*, *Cavalière*, *Chrétienne A*, *Dramont C*, *Planier III*, *Plane I*, *Roche-Fouras*).

But it must be stressed two points: first, at *Baie de Briande*, *Chrétienne A*, *Planier III* et *Plane I*, treenails are crossed by iron nails; second, at *Cavalière* et *Roche-Fouras*, they are associated with assembly stitches. Therefore it is probable that using of a softwood for treenails refers to a secondary function in this sort of joint.

Geographical origin

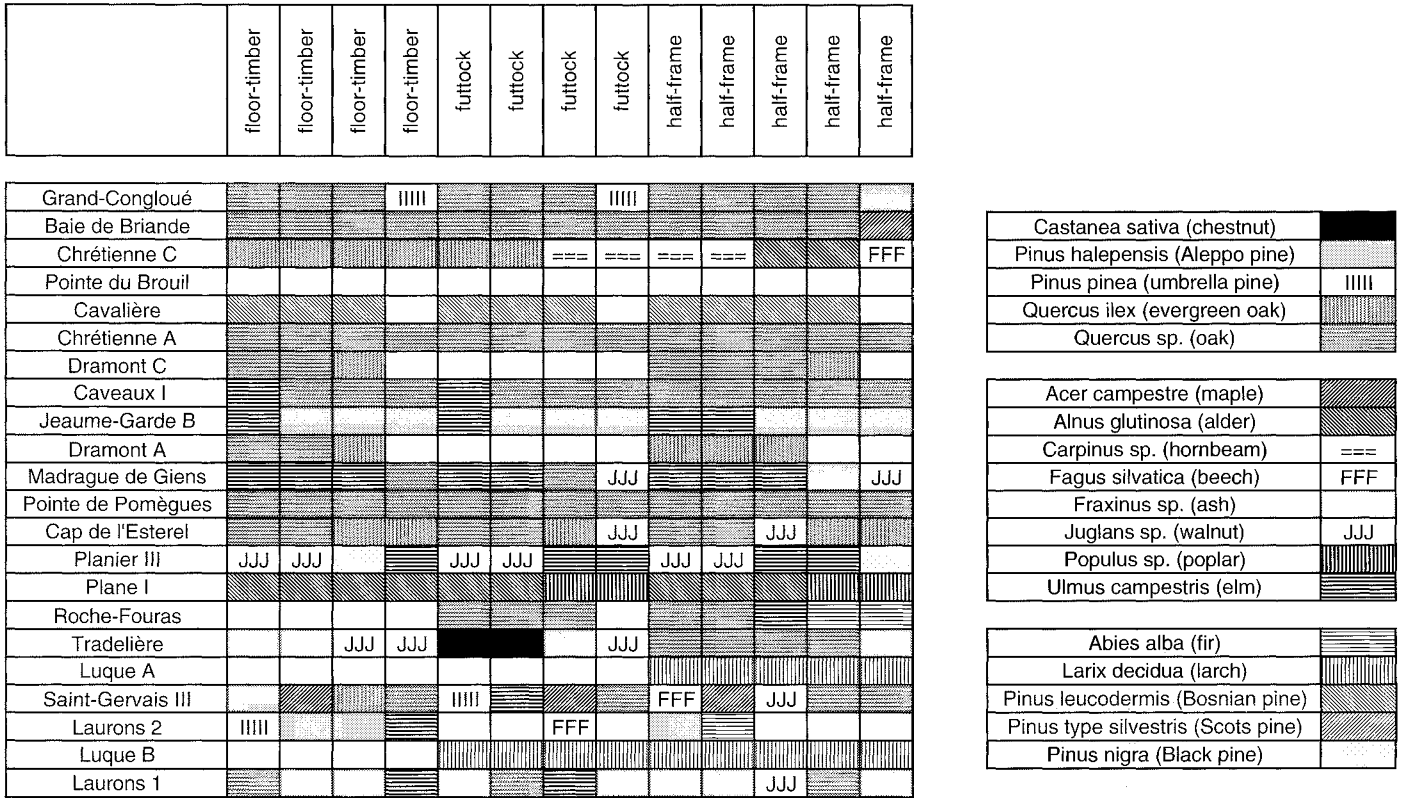
Tree species identified on each wreck come from so diverse biogeographical areas that they do not allow us to precise any geographical location about the shipyard where the ship was built. Nevertheless interpretation can be attempted about *Pointe de la Luque B* and *Cavalière* which both are very homogeneous.

Indeed, apart joinery elements most of the hull pieces are made of larch at *Pointe de la Luque B* and Bosnian pine at *Cavalière*. Considering the geographical distribution area of these two species, in montane and subalpine vegetation stage (from 1200 m of altitude until the upper tree limit), rather far from the coastal areas, they do not appear much convenient for supplying a shipyard. But in fact, given these species geographical distribution area was in the Ancient times the same as it is now, some maritime areas may have been supplied with such timber. Considering the wreck location, hypothesis of *Pointe de la Luque B* constructed on Provence, Liguria or Venetian seashores may be expressed as larch stands are distant only by 35 km in the Maritime Alps, 140 km from Marseilles and 70 km from the Adriatic sea. As far as *Cavalière* wreck is concerned, hypothesis of construction along the Campania, Calabria or Illyria seashore with Bosnian pine stands which were not far by more than 50 km is also possible. In both cases, timber may have been floated until shipyards.

Therefore, homogeneous taxonomy of these two wrecks and restricted geographical distribution area of larch and Bosnian pine make it possible to assess a geographical origin for timber and hence, a potential ship building area. In both cases, importing of valuable mechanical timber attests high care in ship construction.

Conclusions

To sum up these results, on one hand, a small number of species identified on a same hull means homogeneity and often quality; on the other hand, a high number of species may reflect as well structure complexity, timber supplying problems or repairs without jeopardizing the structure homogeneity (*i.e. Madrague de Giens* which evidences construction quality and carefulness). Besides that, species diversity as at *Laurons 2* and *Saint-Gervais III* means actual structure heterogeneity and probably a



	floor-timber	floor-timber	floor-timber	floor-timber	futtock	futtock	futtock	futtock	half-frame	half-frame	half-frame	half-frame	half-frame
Grand-Congloué	▤	▤	▤	IIIII	▤	▤	▤	IIIII	▤	▤	▤	▤	░
Baie de Briande	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▨
Chrétienne C	▥	▥	▥	▥	▥	▥	===	===	===	===	▧	▧	FFF
Pointe du Brouil													
Cavalière	⧅	⧅	⧅		⧅	⧅	⧅		⧅	⧅	⧅	⧅	
Chrétienne A	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤
Dramont C	▤	▤	▥						▤	▤	▤	▥	
Caveaux I	☰	▤	▤	▤	☰	▤	▤	▤	▤	▤	▤	▤	▤
Jeaume-Garde B	☰	░	░	░	☰	░	░	░	☰	☰	░	░	░
Dramont A	▤	▤	▥						▥	▥	▥		
Madrague de Giens	☰	☰	☰	▤	☰	☰	▤	JJJ	☰	☰	☰	░	JJJ
Pointe de Pomègues	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤
Cap de l'Esterel	▤	▤	▥	▥	▤	▤	▥	JJJ	▤	▤	JJJ	▥	▥
Planier III	JJJ	JJJ	∴	☰	JJJ	JJJ	☰	☰	JJJ	JJJ	☰	☰	∴
Plane I	▧	▧	▧	▧	▧	▧	‖	‖	▧	▧	▧	‖	‖
Roche-Fouras					▤	▤	▤		▤	▤	☰	≡	≡
Tradelière			JJJ	JJJ	■	■		JJJ	▤	▤	▤	▤	
Luque A									⁞	⁞	⁞	⁞	⁞
Saint-Gervais III	░	▨	▥	▤	IIIII	☰	▨	▤	FFF	▨	JJJ	▤	▤
Laurons 2	IIIII	░	░	☰			FFF		░	≡			
Luque B		⁞	⁞	⁞	⁞	⁞	⁞	⁞	⁞	⁞	⁞	⁞	⁞
Laurons 1	▤			☰		▤	☰				JJJ	▤	

Castanea sativa (chestnut)	■
Pinus halepensis (Aleppo pine)	░
Pinus pinea (umbrella pine)	IIIII
Quercus ilex (evergreen oak)	▥
Quercus sp. (oak)	▤

Acer campestre (maple)	▨
Alnus glutinosa (alder)	▧
Carpinus sp. (hornbeam)	===
Fagus silvatica (beech)	FFF
Fraxinus sp. (ash)	
Juglans sp. (walnut)	JJJ
Populus sp. (poplar)	‖
Ulmus campestris (elm)	☰

Abies alba (fir)	≡
Larix decidua (larch)	⁞
Pinus leucodermis (Bosnian pine)	⧅
Pinus type silvestris (Scots pine)	⧄
Pinus nigra (Black pine)	∴

Fig. 8.4. Identified tree species according to structural element (frames) and wreck.

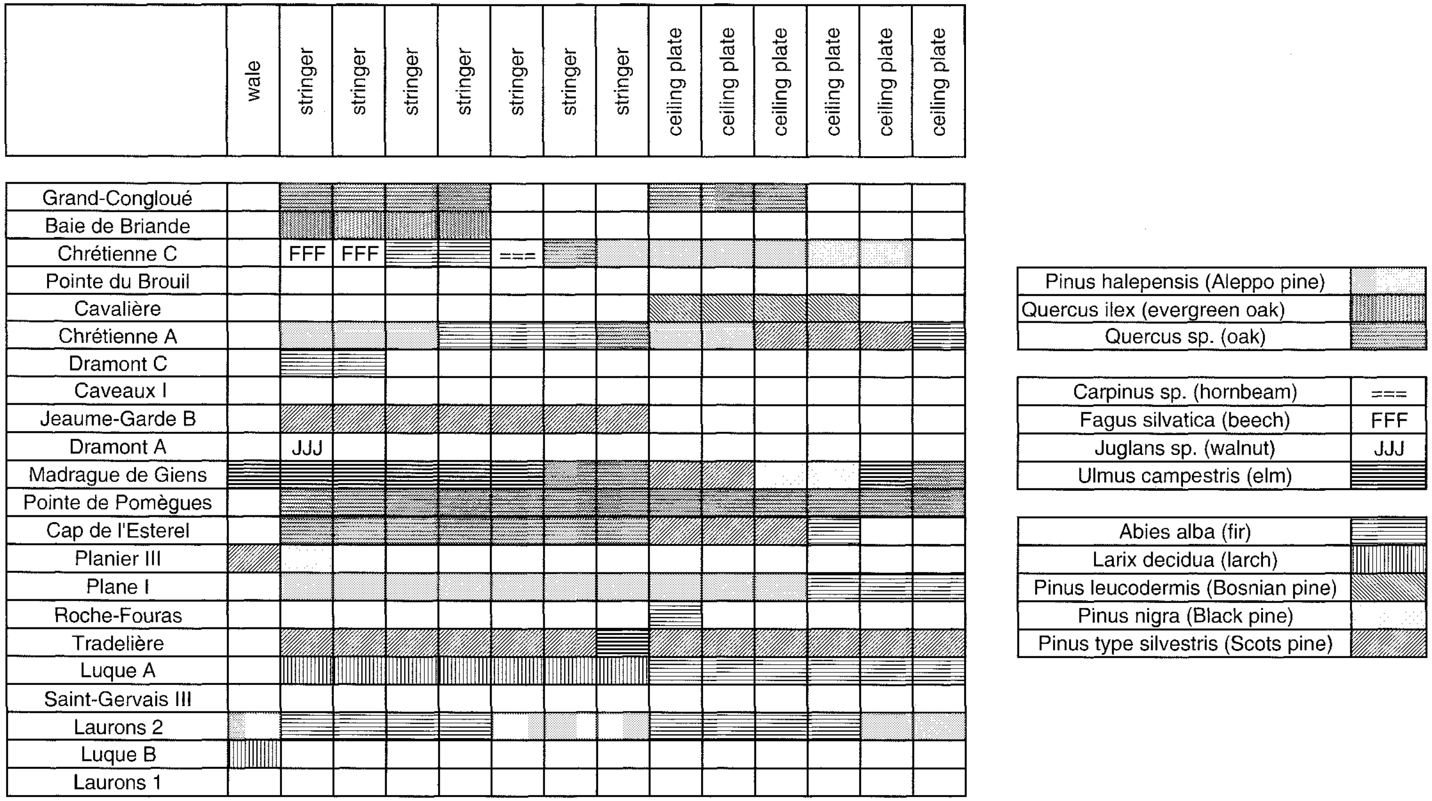


Fig. 8.5. Identified tree species according to structural element (longitudinal) and wreck.

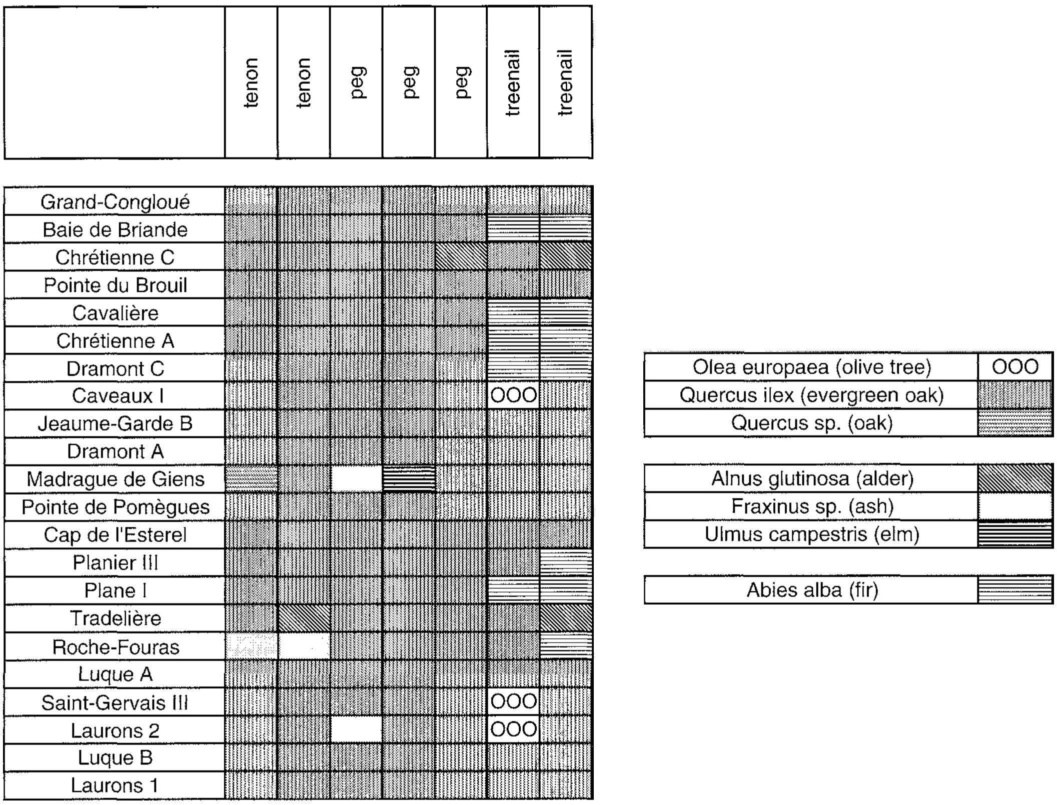


Fig. 8.6. Identified tree species according to structural element (joints) and wreck.

lesser construction care resulting from timber shortage.

Moreover it can be said that homogeneity of axial elements and planking contrasts with the heterogeneity of frames. Less care seems to prevail in frame construction of which the function appears quite secondary when compared to strakes for which much more carefulness is allocated. That does agree quite well with ancient shipbuilding method which is based on shell-first construction in which shell assumes a fundamental function, while frame has a strengthening secondary function (Pomey, 1998). Care taken for hull construction also pinpoints timber supply problem as mountain tree species logs were imported probably by means of river flotation for strakes and axial elements while floor timbers of which the shape make them much less floatable seem to be from local origin.

Last, it does not make much sense in assessing geographical location to the shipyard where the ship was built unless homogeneous taxonomy of the hull and a restricted geographical distribution area for species identified occur together. That is what happens for *Pointe de la Luque B* and *Cavalière* for which potential ship building areas are proposed.

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9. The Late-Roman “Parco di Teodorico” Wreck, Ravenna, Italy: Preliminary Remarks on the Hull and the Shipbuilding

Stefano Medas

During the excavation[1] undertaken to create Theodoric Park in Ravenna, on Nov 6th, 1998, at a site, located at 200 m northwards Theodoric's Mausoleum, a wreck of a late-Roman boat was discovered[2] (Figs. 9.1–9.2). The find was embedded in sand at about 8.50 m under the present land's surface, at a site corresponding to the former Roman and late-Roman seashore line.

Archaeological excavation took place from December 1998 up to February 1999, when the find was completely removed. The works carried out by highly specialized firms, were directed by the Soprintendenza per i Beni Archeologici dell'Emilia Romagna with the cooperation of the Istituto Centrale per il Restauro (ICR).

The job went on with the stratigraphical removal of the hull's internal filling, then with the clearing of the underlying layer, so giving the opportunity of examining the boat bottom outer aspect (Fig. 9.3).

During the excavation, the wreck was sheltered by a double watertight protecting shell. The first one consisted of a silicon rubber coat directly spread on the wood, while the second one consisted of a G.P.R. (glass resin) shell, carefully reinforced by transverse and longitudinal ribs stretched over the first coat in order to obtain a remarkable mechanical resistance, fit to stabilize the wreck.

The underlying ground excavation and the double shell coatings were carried out in the following order: first excavation, second the two above mentioned protecting shells, and last a peculiar basic support consisting in a

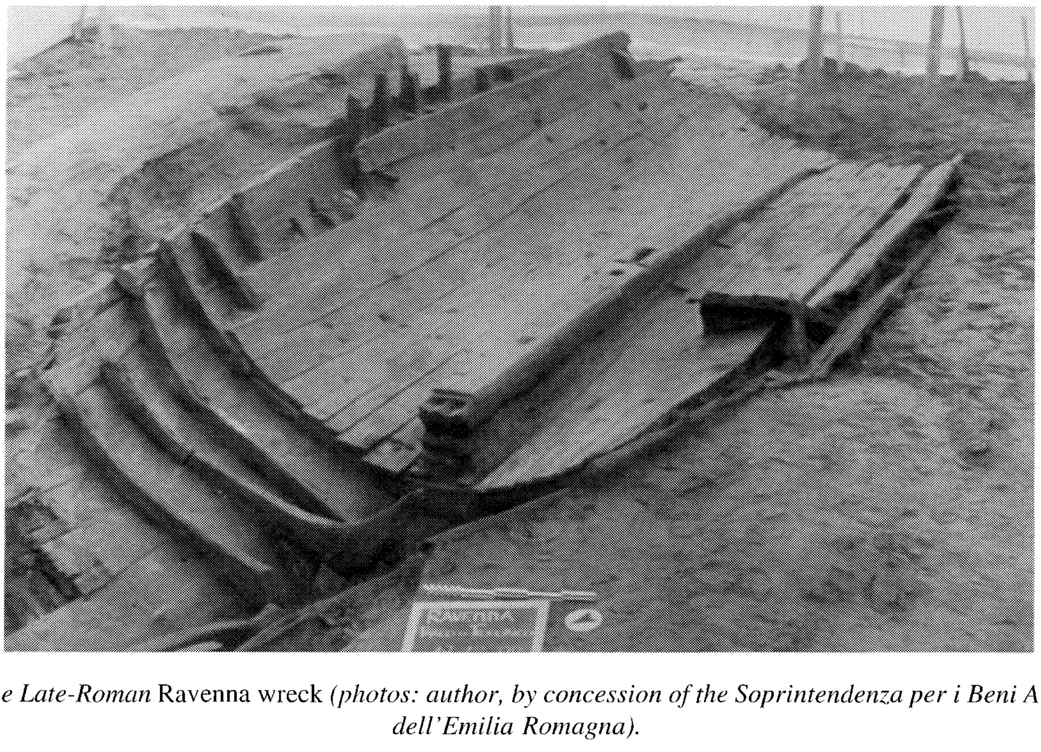
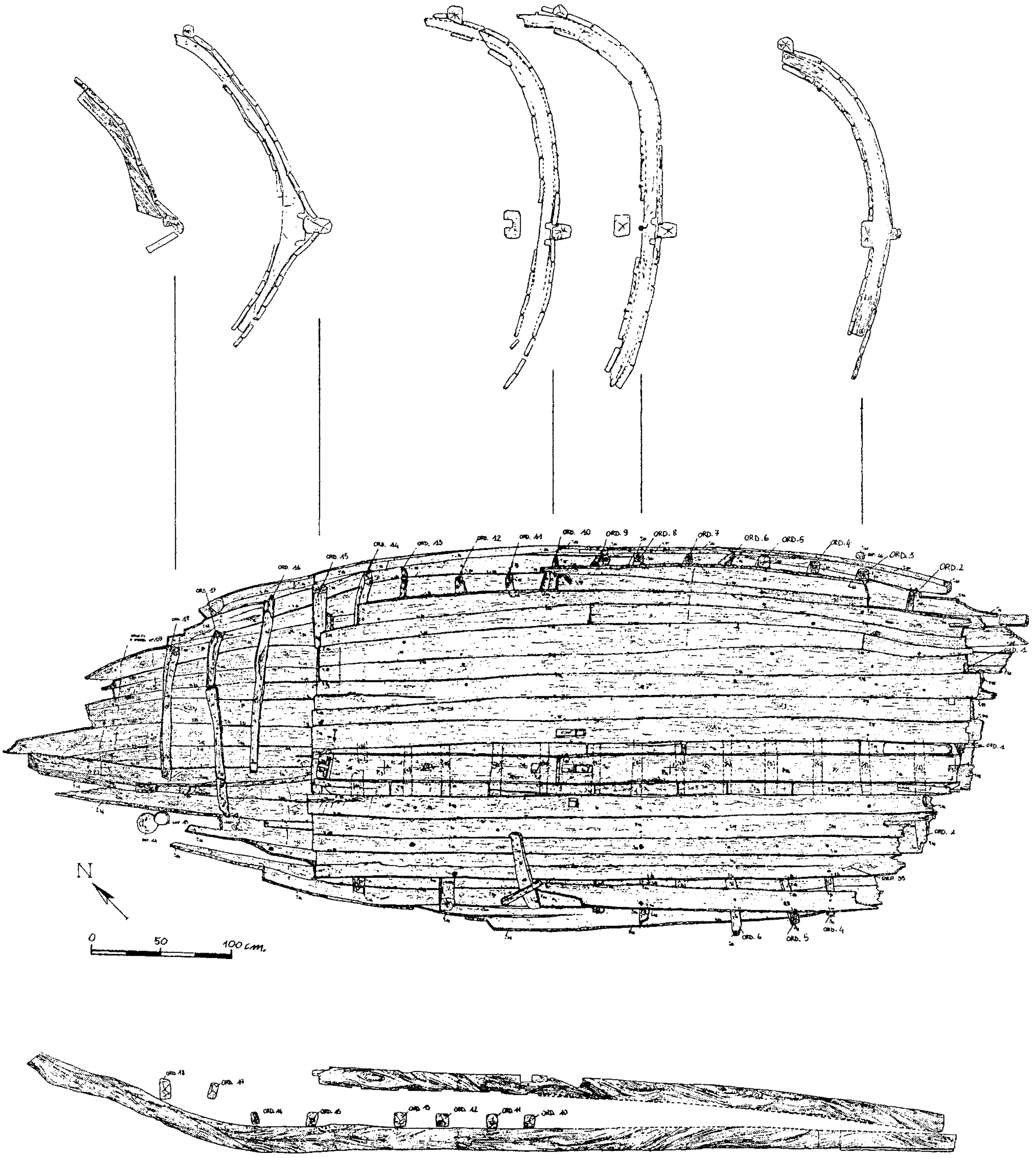


Fig. 9.1. The Late-Roman Ravenna wreck *(photos: author, by concession of the Soprintendenza per i Beni Archeologici dell'Emilia Romagna).*


ORD. 2
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ORD. 15
ORD. 16
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N
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50
100 cm

Fig. 9.2. Ravenna wreck. *Plan, sections (frames), longitudinal section of the keel and keelson (drawing: C. Leoni, La Fenice).*

number of transverse battens fitted on a basic iron structure (Fig. 9.4). The structure was then completed up to the construction of a cage including the whole wreck and shell system. The lot was then carried to the restoration center in Comacchio (Ferrara).

The find was gradually cleared of the sediments lying on the hull upper and lower part, without inflicting it the minimal motion. The adopted method was conceived in order to leave every single structural element exactly in its original location, just like if they were still *in situ*.

The double shell was purposed to obtain, in addition to the immediate protection of the find, the strengthening

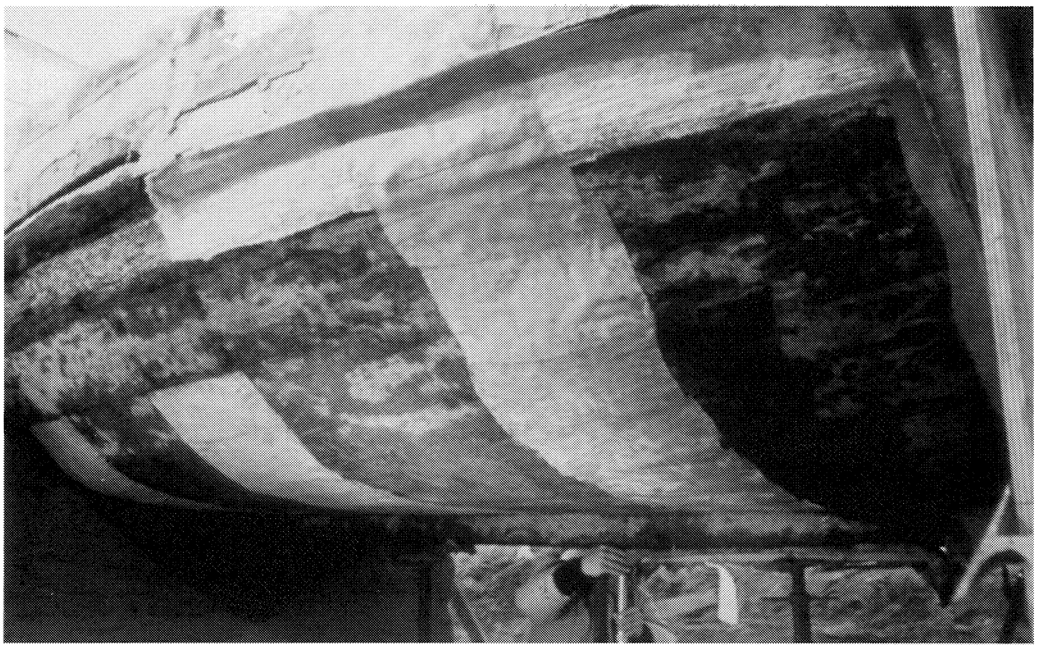

Fig. 9.3. Ravenna wreck. *Underling ground excavation.*

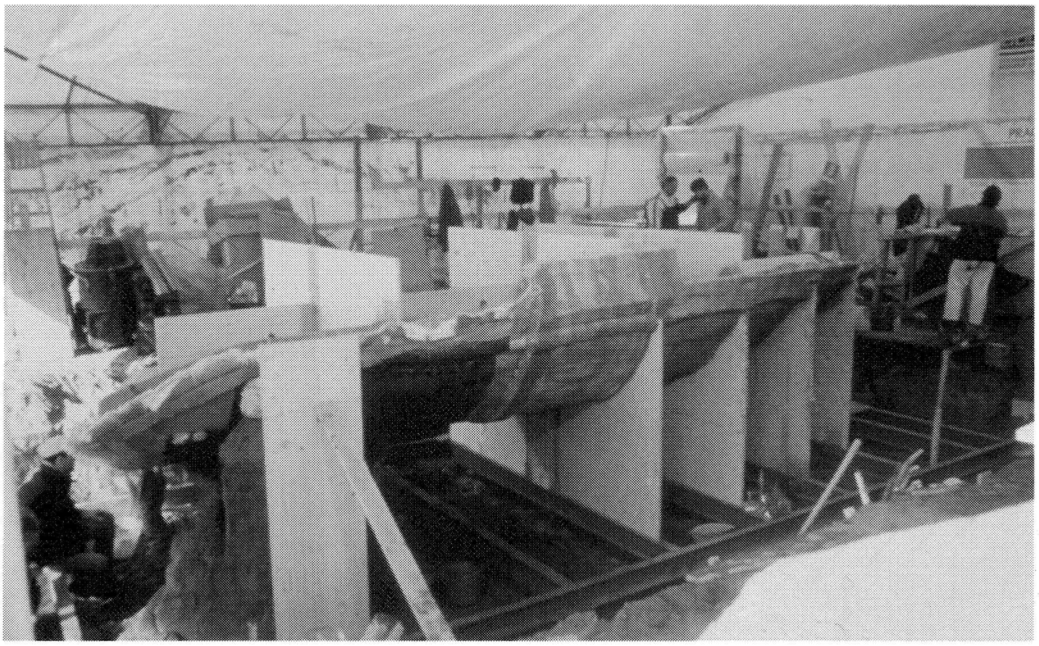

Fig. 9.4. Ravenna wreck. *The finishing of the G.P.R. shell and basic support construction, at the end of the excavation.*

of the wood by the spreading of liquid strengthening solution. To this purpose a system of inlet and outlet channels was realized in the shell, in order to facilitate fluid circulation.

During the fieldwork, visibility of many structural particulars of the boat was partially obscured by the protective original coating covering the external planking. In order to avoid damaging it, a thin layer of concretion was left in place; the same will be removed during the last phase of the restoration (after the opening of the shell).

Frames too were concealed by the presence of internal planking. Since a detailed and complete study of every single structural particular will be brought up to date after the final cleansing, which will take place at the end of the

4 years strengthening period; the following elements are offered as mere preliminary information.

The boat was abandoned on the seashore. Some objects recovered from the hull, partly belonging to the shipment, partly to the boat equipment, allow dating back the wreck up to the 5th century AD.

Among the materials there are fragments of two Syrian produced glass suspension oil-lamps, a glass bottle with a blue turning line of oriental tradition, two next-to oriental production oil-lamps, three African cups, six leather footwear, an iron pan, an iron hook, a wooden rod with an enlarged extremity.

A number of very thin layers characterized the bed of the wreck; several layers of sand, peat, peat and sand mixture, evidenced a succession of passages from the marine coastal environment, to the aerial one, through stages of sedimentation in fresh water stream or lagoon.

The wreck is preserved for a total length of 7.22 m and a maximal beam of 2.75 m. The right broadside is preserved up to the level of the gunwale. The stern was partially cut off by the excavator intercepting the wreck, while the prow, whose bow is still largely intact, suffered a sinking in the sand and was twisted to the right side. Altogether the hull is well preserved, besides a certain amount of deformation due to its embedding in the sand, an event that also caused a longitudinal stretching to the hull.

From a first field observation, a variety of woods seem to have been used during the boat's building: oak for the keel and framing, fir for the internal and external planking, pine for the keelson.

The keelson was found displaced towards the bow into a slightly lifted position, a favorable occurrence that permitted to explore the boat lowest section and facilitated the removal of the sand, which filled the interspace between inner and outer planking (Fig. 9.5). The lifting of the keelson, due to a tight packing of debris, was allowed by the fact that the keelson itself had not been steadily connected with the floor timbers, but the ribs had only been butted into it and the keelson was kept in place only by the pressure of a number of stays.

The mast step is directly carved into the keelson and is located some 50 cm forward, while the steep is shaped with a peculiar slope with the bottom wedged astern, in order to facilitate the mast lowering. The mast itself must have been supported by a beam secured to the hull by means of stringers and carlines fastened to the frames and resting on them. A transversal groove placed in front of the mast's step had been carved in order to accommodate a small board intended to build a simplified step's box, without sideboards. Two additional square shaped steps grooved into internal planking, adjacent to the floor timber, were probably intended to accommodate two stanchions supporting the beam.

The internal planking takes up the central part of the hull, corresponding to the length of the keelson, and is connected by iron nails. Along this tract the boat was open, while the original presence of a short deck ahead and abaft is marked by a series of hollows carved into the gunwale, in order to accommodate the heads of plank shaped beams.

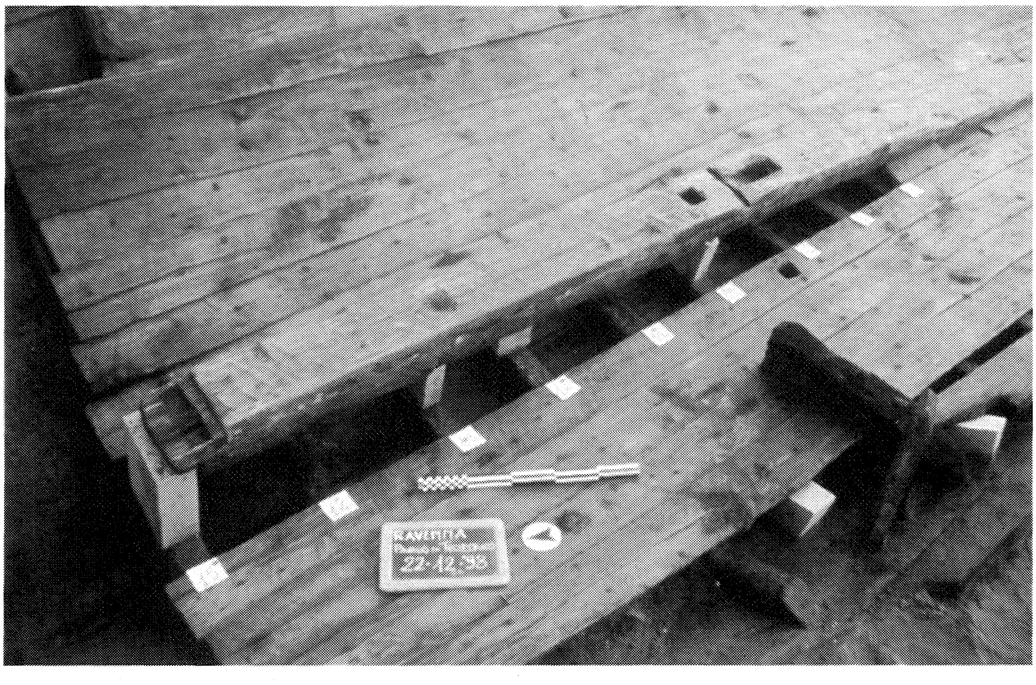

Fig. 9.5. Ravenna wreck. *Hull's inside with the lifted keelson.*

Along both keelson sides there are two rows of loose boards simply lying on the floor timbers forming a dunnage so that the bilge could be inspected, the scuppers could be de-obstructed and the water bailed out.

Only 18 frames are available from the framing, plus the remains of another one at prow (high prow). The frames are composed of floor timbers, simple high ribs without corresponding floor timbers or futtocks. Some floor timbers are nailed down to the keel by iron boat nails.

Side planks are nailed to the frames by iron nails and wooden pegs. The presence of mortise-and-tenon joints was found at least up to the knee level. Tenons are remarkably spaced each other (80 cm about) along the same seam, fitted into much wider mortises, without fastening along a vertical direction, loose and not fastened with pegs (Fig. 9.6). Planking boards were therefore not fastened along a vertical direction and were remarkably loosed also in a longitudinal direction.

Therefore the planking of this construction was not self-bearing, with a substantial difference from the Greek-Roman ships built according to the mortise-and-tenon system. So, the hull stiffness was entirely committed to the framing, in this case, a really bearing structure.

The limited number of tenons was probably used to guide the planking assembling during the building, just to hold the boards in place at least to the knee level.

This wreck is probably testifying one of the last examples of "shell-first" building system during the 5th century AD. While the building system still appears bound to the classical old procedure, on the other side the importance given to the framing as a most important bearing structure shows an evolution towards a new technical advance, which can be considered almost completely as a "bearing-skeleton" construction. More precisely the building plan may be considered as a "mixed-type" one.

This evolution developed along a number of centuries from the 4th up to the 6–7th century AD (Pomey, 1988; 1998). First signs can be traced in the *Yassi Ada II* wreck (Turkey), belonging to the 4th century AD (van Doorninck, 1976), and in *San Giuseppe di Comacchio* wreck (Ferrara) probably dating back to the 4th century AD (Bonino, 1983/1984)[3], both still constructed according to mortise-and-tenon system, but with a remarkable distance between the joints and a very irregular distribution of them. Now, after a new systematic study of the hull, come out the importance of *Fiumicino 1* wreck (Rome), probably dating back between 4th and 5th century AD, where mortise-and-tenon joints were rather spaced and a few of them were unpegged (Boetto, 2000).

Subsequent evolution, characterized by a more thinning of the joints and the absence of pegs in tenons, together with the more frequent fastening of the planking directly on the ribs, is well known due to the wrecks of *Yassi Ada I* (Turkey), 7th century AD (Bass, van Doorninck, 1982), *Pantano Longarini* (Sicily), 6th or 7th century AD (Throckmorton, 1973), and *Saint-Gervais II* (Fos-sur-Mer, France), 7th century AD (Jézégou, 1985; Pomey, 1988: 410–411). New evidence come from the planking timbers of *Dor D* wreck (Tantura Lagoon,

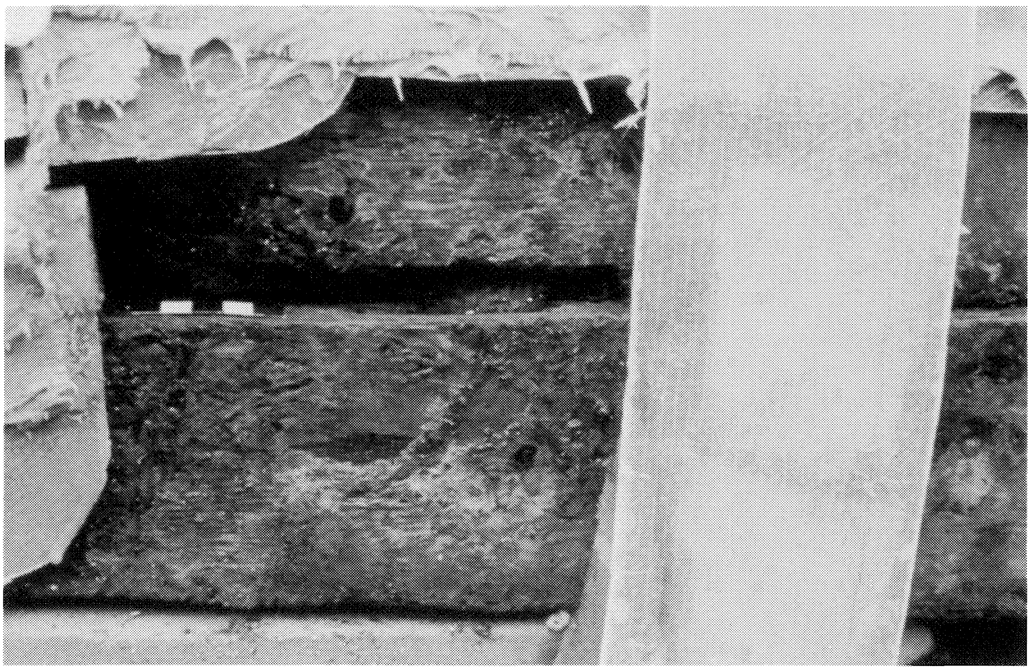

Fig. 9.6. Ravenna wreck. *Unpegged mortise-and-tenon joint.*

Israel), 7th century AD, where mortise-and-tenon joints were unpegged and spaced (Kahanov, in press; Kahanov, Royal, in press).

Recent discoveries anyhow are evidencing that in the Mediterranean environment the transitional period to the frame based construction seems to be finished, even if not totally generalized and, probably, only in small crafts, in the 6th century AD, as proved by the wreck *A* of Tantura Lagoon (Israel) (Kahanov, Royal, 1996; Wachsmann, Kahanov, 1997).[4]

As above mentioned, the hull is smeared by pitch; along the gunwale a large white strip is traced.

The reconstruction of the boat lines (Fig. 9.7), drawn by Marco Bonino, shows that the boat of Ravenna was originally about 9 m in length, 3.10 m in beam and 4.85 metric tons in displacement (see Bonino in Medas, 2001: 120–122). The reconstructed drawing of the boat shows a correctly water-lined hull with an almost flat bottom at mid-ship and sharps extremities, well fit for sea and shallow waters navigation, as it was necessary along the Ravenna coast.

Notes

[1] The author is member of Istituto Italiano di Archeologia e Etnologia Navale (ISTIAEN).

[2] An extensive preliminary report on the find and hull is in Maioli (2001) and Medas (2001).

[3] This very fragmentary wreck was discovered out of its archaeological context. We suggest a chronology of 4th century about by the comparison with the mortise-and-tenon joints feature of *Dramont F* (Joncheray, 1975) and *Yassi Ada II* wrecks, both dating to the 4th century AD.

[4] This transitional period to the frame based construction (skeleton-first) seems to be finished in large vessels in the early 9th century AD at least, as indicated by the *Tantura B* wreck (Kahanov, 2000).

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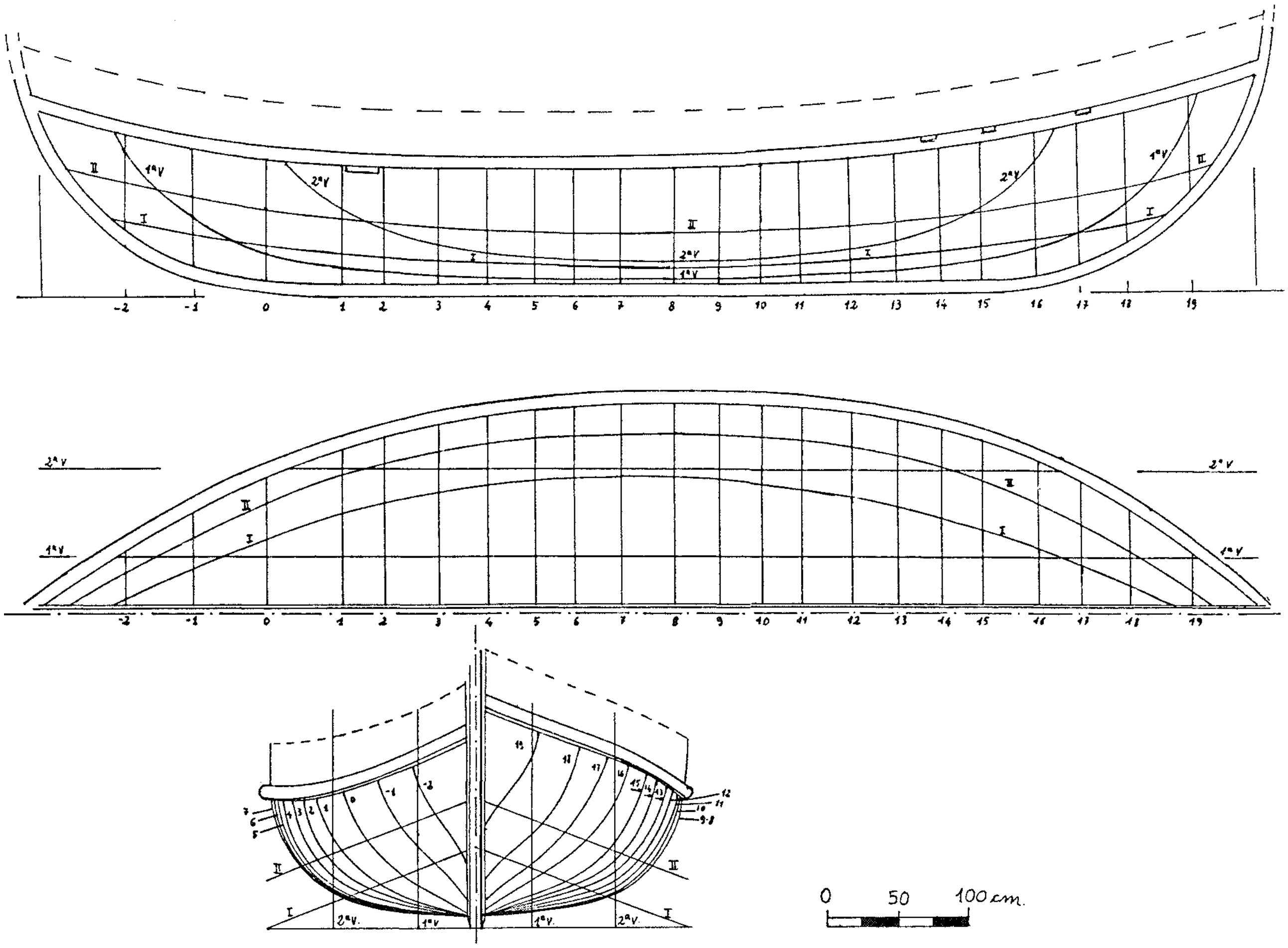

Fig. 9.7. Ravenna wreck. *Hull lines reconstruction (drawing: M. Bonino).*

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10. Dor D Wreck, Tantura Lagoon, Israel

Yaacov Kahanov

Introduction

Tantura lagoon is located on the Mediterranean coast of Israel, 30 km south of Haifa. It is a natural cove to the south of the ancient Dor promontory. For many years the lagoon has been a fruitful area for archaeological survey and during the last few years for underwater excavations and research (Wachsmann, 1995; Kingsley *et al.,* 1996; Wachsmann *et al.*, 1997a; 1997b).

Preliminary reports on two of the wrecks that were excavated in Tantura – *Tantura A* and *Tantura B* – were presented on previous occasions (Kahanov, 1996; 2000). Since then additional wrecks and information have been revealed.

Recently, a wreck designated as *Dor D* was excavated; its finds are relevant to the two mentioned previously and contribute further information for the understanding of the change in ship construction methods during the second half of the first millenium AD.

J. R. Steffy (1994) established the basic hypothesis for the "transition in construction" of ships in the Mediterranean, although the idea was mentioned earlier (see Bass, 1982: 312). Specifically, the transition from "Shell first" to "Skeleton first" was described or as refined later by S. McGrail (1997), from "Plank first" to "Frame first". Steffy suggested that the first stage of the change is evident in the *Yassi Ada* wreck of the 4th century (Van Doorninck, 1976). The change continued through the 7th century as is evident from the *Yassi Ada* wreck (Van Doorninck, 1982). The transition was completed by the beginning of the 11th century, as is evident from the Serçe Limani *"Glass Wreck"* (Steffy, 1982).

Subsequently, a combined expedition of the Institute of Nautical Archaeology at Texas A&M University and the Recanati Institute for Maritime Studies at the University of Haifa, directed by S. Wachsmann, excavated the wreck known as *Tantura A*.

Tantura A

Tantura A was excavated during the 1994 and 1995 seasons and for a short time during the season of 1996 (Kahanov *et al.,* 1995a; 1995b; 1996) (Fig. 10.1). It was a small coaster, of frame-based construction that, according to C14 and ceramic analysis, was dated to the 6th century AD. It had a rectangular keel 11 cm sided and 18 cm molded, hook-scarfed to a naturally curved Aleppo pine endpost. Evidence of 24 frames was identified, eight of which were extant wood, and the rest staining patterns. They were, on the average, 9 cm sided, 9.5 cm molded and 32.5 cm center-to-center spaced. Nail concretions and nail holes confirm that the frames were fastened to the keel by iron nails (Fig. 10.2). Remnants of at least eight strakes have survived; they were 2.5 cm thick and between 4 and 26 cm wide. The planks were butt-scarfed at frame stations and each plank-edge was nailed to the frame (Fig. 10.3). Iron nails, driven from the outside, were used to fasten the planks to the frames; the garboard was neither fastened nor nailed to the keel. There were no mortises, tenons or treenails observed anywhere. Caulking was evident in the planking seams (Fig. 10.4).

As this vessel pre-dates any known, to date, archaeological parallel, it is, at present, the earliest evidence in the Mediterranean of the transition from a plank-based mortise-and-tenon hull to some form of skeletal-frame-based construction. It predates the Serçe Limani *"Glass Wreck"* by almost five centuries, but it was a small vessel. It is likely that changes and transformations in construction methods would first be tried in small, local craft, rather than in bigger sea-going merchantman.

Tantura B

Tantura B was revealed in 1995 and thoroughly excavated during the 1996 season (Wachsmann *et al.,* 1997b; Kaha-

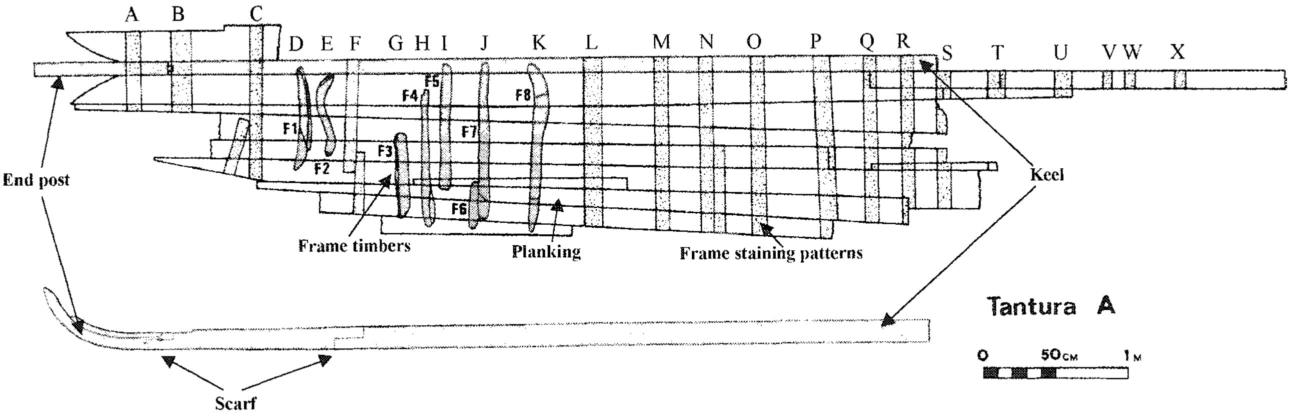
A B C D E F G H I J K L M N O P Q R S T U V W X
F1
F2
F3
F4
F5
F6
F7
F8
End post
Frame timbers
Planking
Frame staining patterns
Keel
Tantura A
0 50cm 1m
Scarf

Fig. 10.1. Tantura A: top view, and side view of the keel (drawing: P. Sibella and S. Ad).

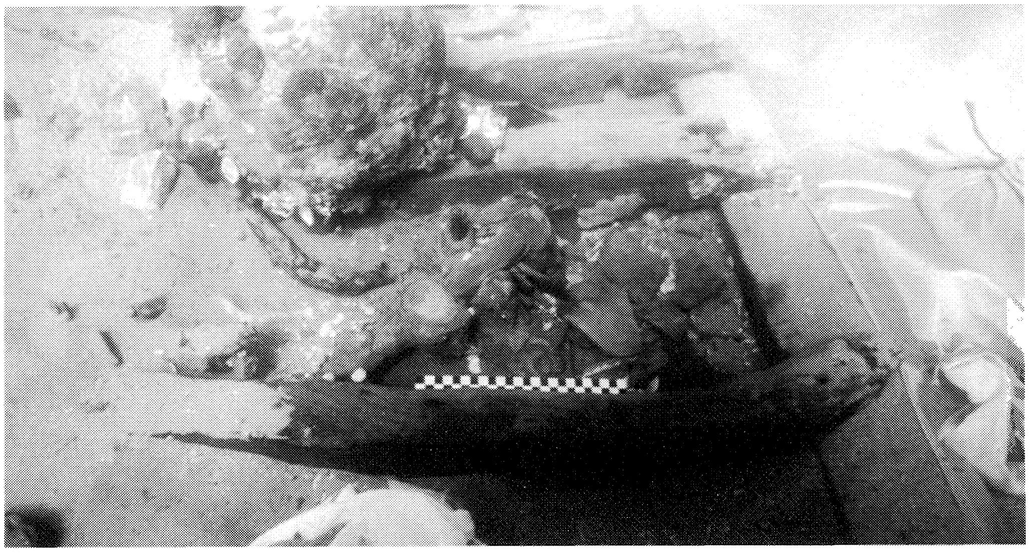

Fig. 10.2. Tantura A: frames nailed to the keel (photo: S. Wachsmann).

Fig. 10.3. Tantura A: nail concretions and nail holes in planking (photo: S. Wachsmann).

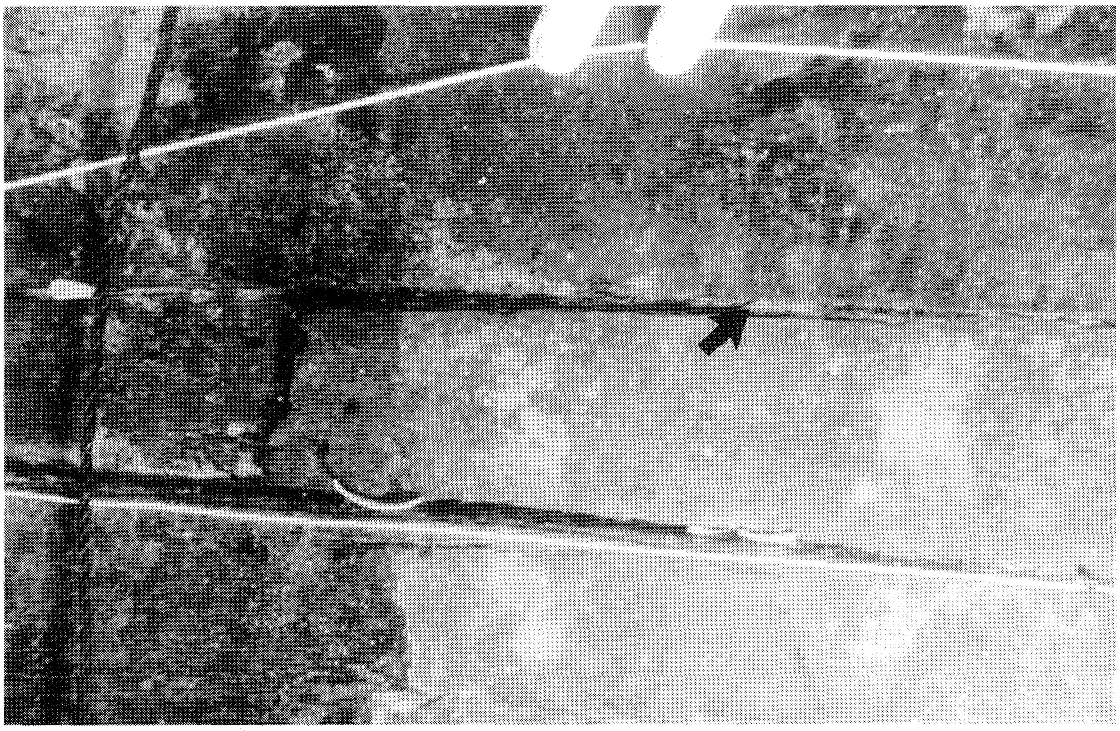

Fig. 10.4. Tantura A: seam caulking (photo: S. Breitstein).

nov, 2000,) (Fig. 10.5). She was a larger ship, in comparison with *Tantura A*, and was estimated at about 23 meters long. C14 tests of wood samples and finds analysis, including ceramic, dated this wreck to the beginning of the 9th century AD. She had an oak keel 11 cm sided and 10 cm molded and an Aleppo pine keelson 20 cm sided and 18 cm molded. 40 alternating floor timbers and overlapping half-frames were recorded, 30 of which were extant wood. The frames were, on the average, 9 cm sided and 9.4 cm molded, with centers spaced 26 cm apart. They were iron nailed to the keel and keelson. Remnants of 12 Aleppo pine strakes were preserved. The strakes varied between 5 to 36 cm in width and were about 3 cm thick. The garboards just touched the keel, but were not connected to it. The planks were butt-joined at frame stations and iron-nailed to the frames (Fig. 10.6). Caulking was evident in the plank seams. No mortises or tenons were identified anywhere.

All this is an indication that the vessel was of frame-based construction.

Therefore this ship can once again advance the transition date, this time by only two centuries, but on a larger craft. Despite the fact that this vessel demonstrates a frame-based construction, it could be argued that it does not possess enough longitudinal strength, and thus is still not "skeleton built" in the full sense of the definition. This question could have been resolved by its upper hull section, of which we have no archaeological evidence.

Dor D

In 1999 another wreck, *Dor D*, was excavated (Fig. 10.7). The existence of this wreck had been known for several years, but it was never thoroughly studied (Kingsley *et al.*, 1996: 64–65). The site spread over an area of 4 by 6 m and was composed of a stone heap, which naturally emerged randomly out of the seabed, 30 m from the shoreline in shallow water 2 m deep. Poorly preserved scattered timbers, apparently hull planking, were found within this heap. C14 analysis of the wood and associated pottery provisionally date the wreck to the mid 7th century AD. Remnants of 14 strakes were recorded. However, no evidence of frames, keel, or other timbers was found.

The planks were, on the average, between 2 and 2.5 m long, and varied between 2 and 3 cm in thickness, and a few were at least 20 cm wide. Unpegged mortise-and-tenon joints were evident in plank edges (Fig. 10.8). They were spaced between 18 and 62 cm, 29 cm on the average. A typical mortise was 6.3 cm wide, 0.5 cm thick and 3 cm deep. The tenons occupied about 2/3 of the mortise length, reminiscent of the 4th century *Yassi Ada* wreck (Van Doorninck, 1976). Though no remnants of framing timbers survived, some evidence of staining patterns and scoring marks, relating to the sided and spacing dimensions was found. The sided dimension was estimated at 10–11 cm and the frame spacing was about 23 cm. The planking exhibited evidence of the use of both nails and treenails.

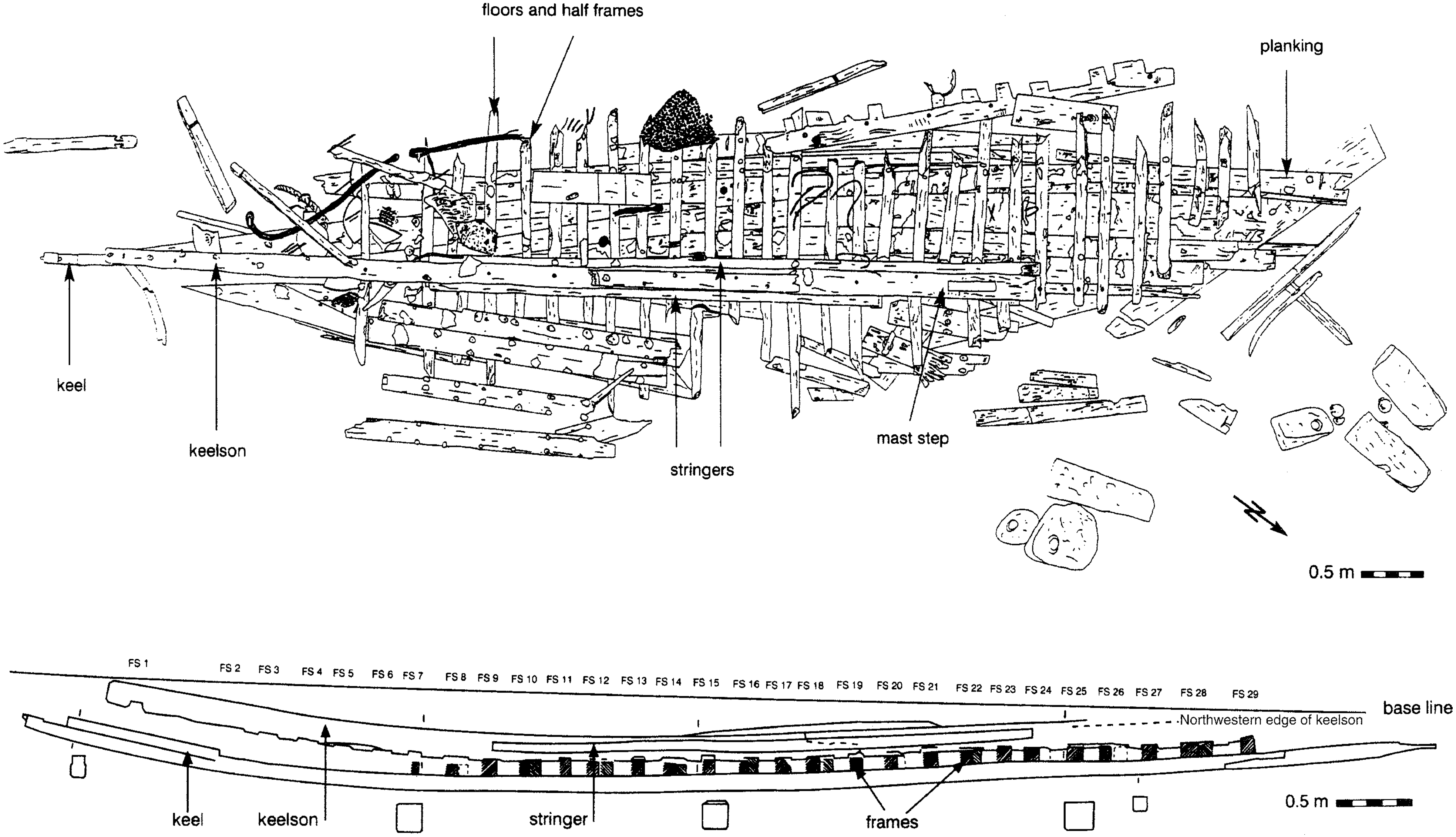
floors and half frames
planking
keel
keelson
stringers
mast step
0.5 m
FS 1
FS 2
FS 3
FS 4
FS 5
FS 6
FS 7
FS 8
FS 9
FS 10
FS 11
FS 12
FS 13
FS 14
FS 15
FS 16
FS 17
FS 18
FS 19
FS 20
FS 21
FS 22
FS 23
FS 24
FS 25
FS 26
FS 27
FS 28
FS 29
base line
Northwestern edge of keelson
keel
keelson
stringer
frames
0.5 m

Fig. 10.5. Tantura B: top view and side view (drawing: P. Sibella).

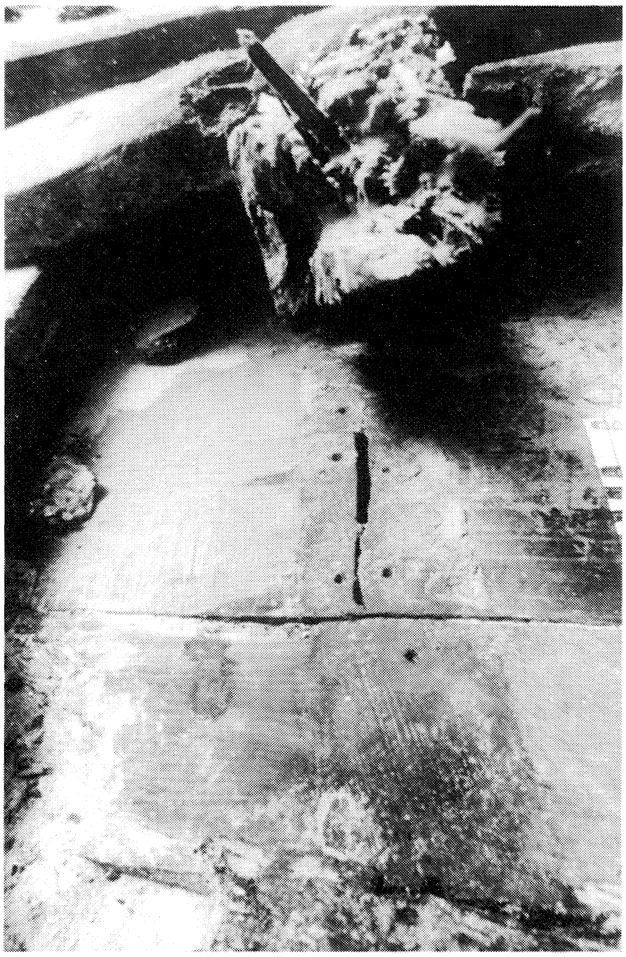

Fig. 10.6. Tantura B: planking scarf and nailing at frame station (photo: S. Breitstein).

At least one treenail was found at each frame station, but nails were much less frequent. One straight diagonal scarf of planking was identified. It was mortise-and-tenon jointed and many nails were found nearby. On this plank, close to the scarf, was found the sole tenon that was secured in its mortise by a wooden peg (Fig. 10.9).

The loose and unpegged mortise-and-tenon joints could not have served as the primary method of joining the hull strakes: rather they assisted in aligning the planks. Thus there must have been some pre-erected supports, possibly frames, onto which the planks were attached. Once in place, iron nails were apparently used to temporarily fasten the planks to a few frames, and later, additional treenails secured them permanently. Further evidence for this sequence was found in a few mortises, which had nails or treenails penetrating the mortise, and just missing the tenon.

Although we are lacking enough information; taking into account the sided dimensions of the frames and their spacing, the use of mortise-and-tenon joints for alignment, the thickness of planks and that some reached a width of 25 cm, we can say that the *Dor D* vessel was probably a medium-sized vessel, possibly 15–20 m in length.

Conclusions

The evidence relating to the constructional features of *Dor D* proves that the development in shipbuilding between the 4th and the 11th centuries was more complicated and that the simple linear chronological transition cannot be supported. On one hand, the unpegged mortise-and-tenon joints extend the evidence found in the slightly earlier *St. Gervais II* (Jezegou, 1985; 1989) and the 7th century *Yassi Ada* wrecks; on the other hand the earlier *Tantura A* did not have any mortise or tenon joints. Unlike *Tantura A* and *Tantura B* that pre-date the building evolution trend, *Dor D* provides a constructional element that moves the typology to a later period.

The single occurrence of the pegged tenon indicates that the concept of using such an attachment, as used in the 4th century Yassi Ada, was not lost to shipwrights of the 7th century. In this case the building typology moves about three centuries later.

In addition, treenails for frame-plank attachments were considered to be a disappearing technique. They were used on the *St. Gervais II* wreck, but not on the *Tantura A, Yassi Ada* or the *Tantura B* wrecks. They exceptionally appeared on the *Serçe Limani* vessel of the 11th century, although they were relatively small and apparently introduced at a later stage, maybe for repairs (Steffy, 1982 and pers. comm.). However, treenails, recently evident on *Dor D* and on the 9th century *Bozburun* vessel (Hocker, pers. comm.) indicate their use on the *Serçe Limani* wreck as a continuing technique.

Even from these few observations, it is evident that arguments regarding construction trends cannot only or primarily be made within the boundaries of chronological periods. Future hypotheses must take into consideration additional factors such as geographical setting, culture, politics and economy.

Analysis of more shipwrecks of the period, based on the minute study of hull components and construction methods, as well as more precise discrimination of the origins of wrecks, is needed.

It is possible that this is similar to human behavior, adopting progressive transitions and changes, but combining these changes with opposing, more conservative, reactions.

Acknowledgements

Dor D was a combined expedition with the participation of the Nautical Archaeology Society of Great Britain, the Dor Maritime Archaeological Project and the Recanati Institute for Maritime Studies at the University of Haifa. The analysis of the wreck was carried out together with Jeff Royal.

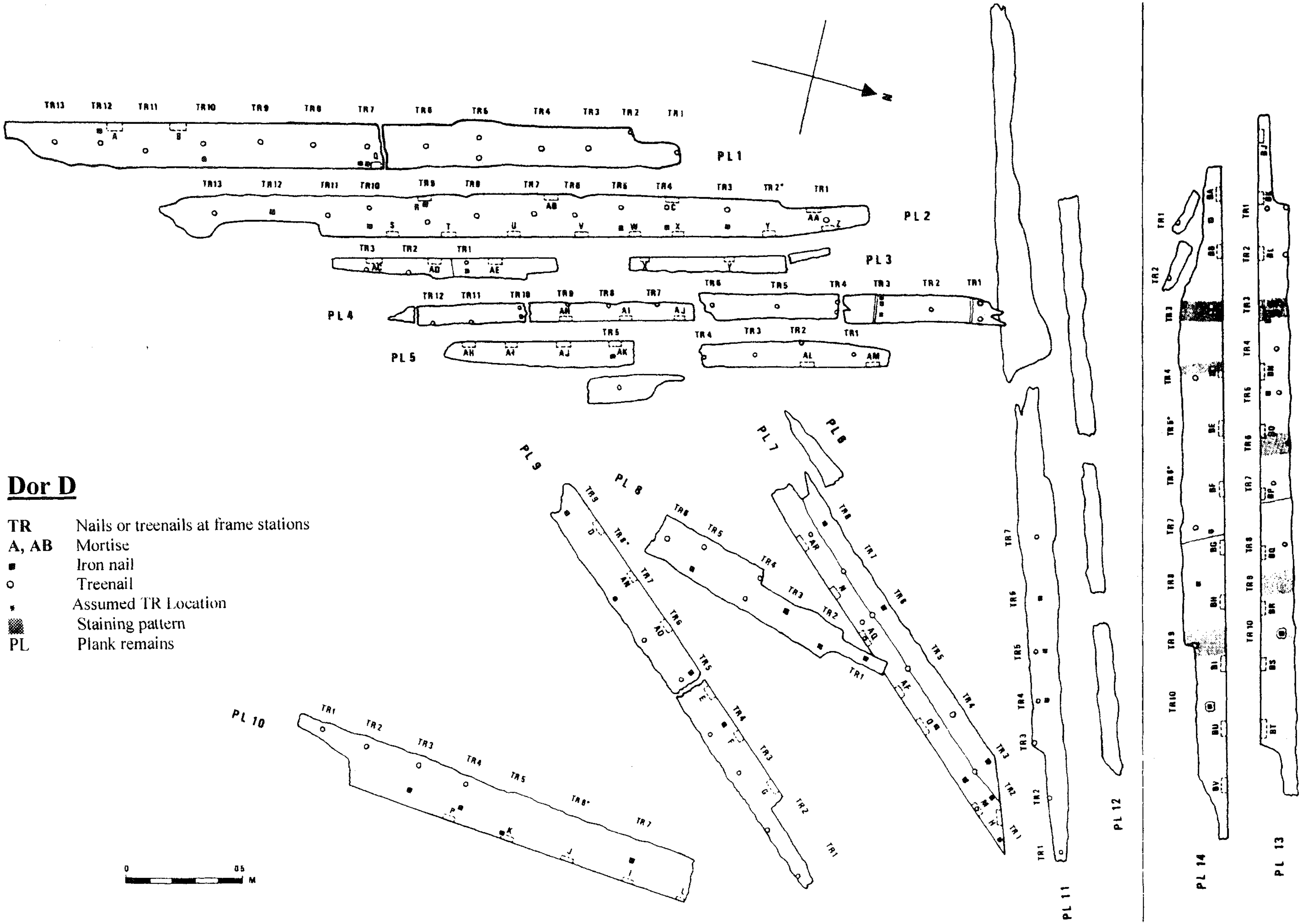
Dor D
TR Nails or treenails at frame stations
A, AB Mortise
■ Iron nail
○ Treenail
* Assumed TR Location
▨ Staining pattern
PL Plank remains
N
PL 1
PL 2
PL 3
PL 4
PL 5
PL 7
PL 8
PL 9
PL 10
PL 11
PL 12
PL 13
PL 14
0
0.5
M

Fig. 10.7. Dor D: planking details (drawing: S. Ad).

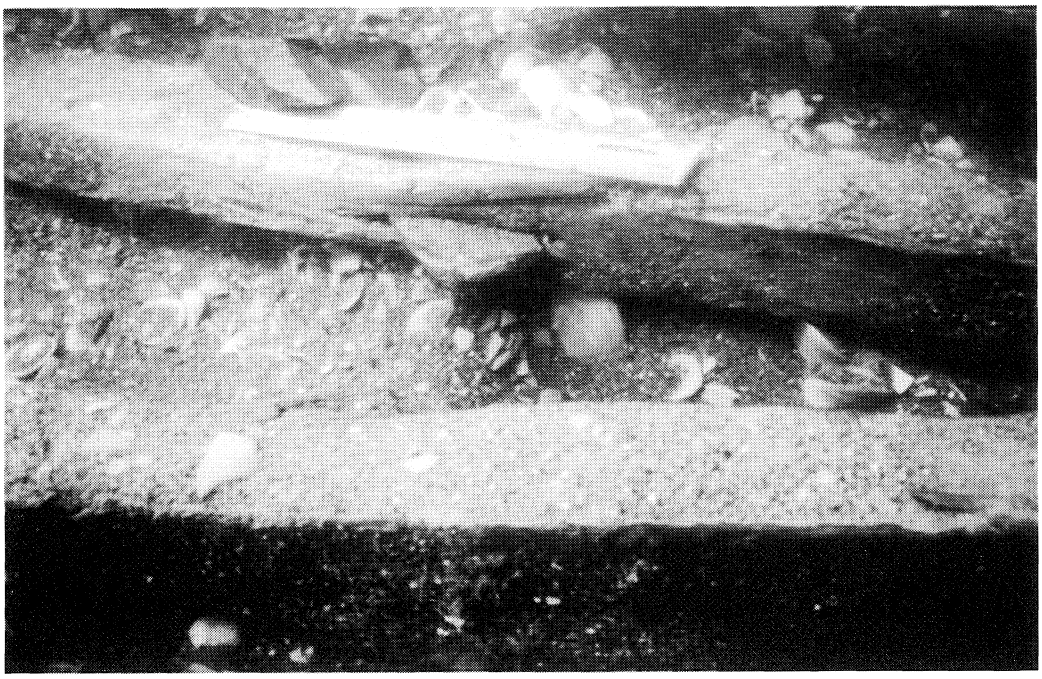

Fig. 10.8. Dor D: unpegged mortise-and-tenon joint (photo: S. Breitstein).

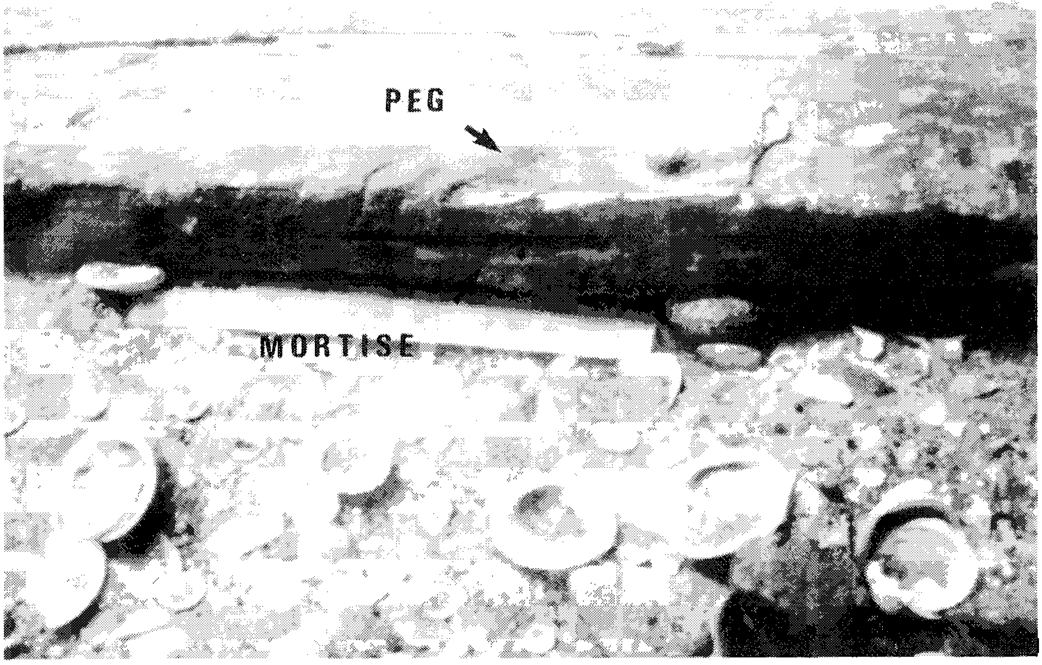

Fig. 10.9. Dor D: the pegged tenon (photo: F. Henseler).

The *Tantura A* and *Tantura B* wrecks were jointly excavated by expeditions from the Instititute of Nautical Archaeology at Texas A&M and the Recanati Institute for Maritime Studies.

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11. Reconstruction of Marseilles 6th century BC Greek ships

Patrice Pomey

Introduction

Following the discovery of two archaic Greek late 6th century BC shipwrecks during the Place Jules-Verne excavation in summer 1993 (Hesnard, 1994; Pomey, 1995), an important research program has been undertaken in order to promote shipwrecks from excavation until the museum. Besides excavating of the shipwrecks in the field and drawing them out of the sediment prior to their conservation treatment for museographical purpose[1], this program carried out by the Centre Camille Jullian[2] aimed more particularly in achieving the archeological analysis of remains and their interpretation, then the final reconstruction of the two initial ships. During the *7th ISBSA* which was held on Tatihou Island (France) in 1994, I had reported main archaeological characteristics of these shipwrecks (Pomey, 1998). Then, at the international Symposium "*Le temps de l'innovation*" in Aix-en-Provence in 1996, I had underlined how important they were for studying ancient shipbuilding techniques evolution (Pomey, 1997a). Lastly, during the *8th ISBSA* in Gdansk (1997), I had reported the first preliminary studies to reconstruct the ships. Final result will be reported here.

The reconstruction program of the ships aims not only in restituting hull lines and the whole structure of the hull but also in reconstructing the propulsion and steering systems. Namely, it must allow on one hand to assess nautical characteristics of the ships, and more particularly hydrostatic and hydrodynamic properties, on the other hand to be the basis of a possible sailing replica.

In order to assure its scientific exactness, this program is based on some principles related to the acquisition and the validation of data used for reconstructions. Namely, priority is given to primary archeological data (remains). Any reconstruction must integrate them taking into account their particularities whatever the difficulty may be. In compensation, using of comparative data (archeological, iconographical or ethnographical) is only admitted once their relevance is proved. On principle, reconstructions only address elements for which it is possible to express hypotheses based on argued data apart any unwarranted reconstruction.

On a methodological point of view, the program is based on the permanent matching between graphic reconstructions and, following the method developed by J. R. Steffy (1994), on study models. This matching aims at checking, making clear and validating proposed reconstructions. Thus several models are carried out throughout the many stages of the reconstruction study.

Preliminary stage

Besides working out graphic data acquired during the excavation of the shipwrecks (general map, longitudinal and cross sections, detailed drawings...), a first model of the general conditions of archeological remains of each wreck is built up. As far as the two archaic Greek shipwrecks *Jules-Verne 7* and *9* are concerned, these models were realized at a 1:10 scale which was chosen because of its convenience and its compatibility with the whole drawings (Fig. 11.1). In order to obtain the necessary maximal accuracy, these models were built from photogrammetric drawings carried out during the excavation[3] which make it possible to obtain a tridimensionnal reconstruction of remains completed by detailed drawings. These models of remains aim at materializing the state of conservation of the shipwrecks showing the relative position of every piece and evidencing gaps and distortions. They also permit to obtain the developed drawing of each strake of the hull planking which are essential for the next stages of reconstruction (Fig. 11.2).

Reconstruction of hull lines

This is by far the most time-consuming and the most difficult stage. In a first step, it includes a first proposition of graphic reconstruction of hull lines limited to the

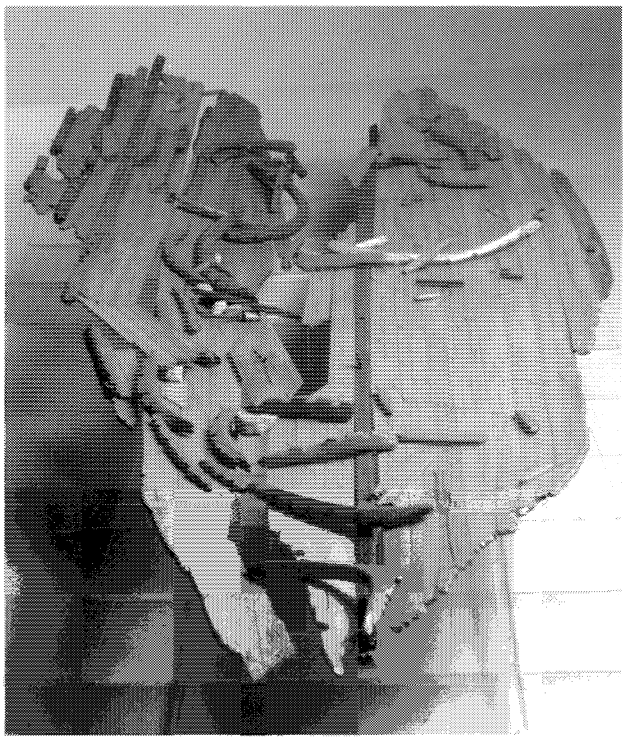

Fig. 11.1. Jules-Verne 7 *shipwreck. Model of archaeological remains (1:10) (author: R. Roman, Centre Camille Jullian, CNRS).*

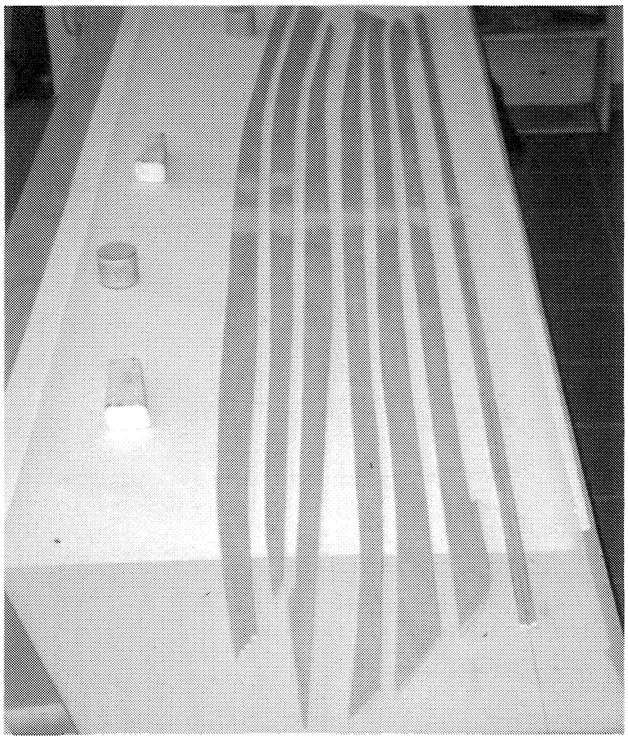

Fig. 11.2. Jules-Verne 7 *shipwreck. Developed strakes of the hull planking (drawing: M. Rival, Centre Camille Jullian, CNRS).*

archeological remains. This reconstruction is achieved on the basis of available cross sections which are laid on the keel according to the longitudinal section. That supposes longitudinal and transversal distortions of the hull remains to be corrected and keel line to be determined. These corrections are made step by step, using the less distorted elements, until a right coherence of the straightened remains be obtained. Regarding the determination of the keel line (straight or rockered), it is based on the analysis of archeological remains completed if necessary by comparative data. This first reconstruction yields a three-views plan (cross section, side view and top view) more or less partial according to the state of conservation of the remains. From this graphic reconstruction, a model is built up to check its relevance and, if necessary, to correct it. On principle, it is admitted that the proposed reconstruction is validated when one gets a complete adaptation of the developed drawing of the hull planking – which is obtained from the developed shape of each conserved strake present on the model of the archaeological remains – on the reconstructed shapes. As long as such an adaptation is not reached, shapes are corrected until adaptation searched for is obtained.

In the example of *Jules-Verne 9*, this model of reconstructed remains was made at a 1:10 scale, this scale being good enough given the state of the remains (Fig. 11.3). On the other hand, as far as *Jules-Verne 7* is concerned, after a first attempt using a 1:10 scale, it was necessary to use a 1:5 scale which was more precise and more fitted to the many data to integrate. Nevertheless another model was *a posteriori* made using a 1:10 scale in order to satisfy display requirements.

In a second stage, reconstructed shapes which were so far restricted to the only archeological remains are extrapolated to the whole hull. That implicates hull limits (length between perpendiculars, breadth at the main beam, depth, sheer line...) are first specified by means of interpreting archeological data or extrapolating and comparing with other archeological, iconographical or ethnographical sources. Obviously, at this stage of the study, such an approach already supposes the ship type, its propulsion system, its function and its sailing area to be defined, all these parameters significantly influencing the hull shape. Method used is identical to that used at the previous step; it proceeds by means of graphic reconstructions which are then checked, modified and validated by building a model.

As regard *Jules-Verne 7* and *9*, reconstruction models of the whole shapes were carried out at a 1:5 scale in order to benefit from a scale significant enough. Whereas regarding *Jules-Verne 9* it happened necessary to use another model, regarding *Jules-Verne 7*, on the other hand, the previous model was used by completing it to the rest of the hull (Fig. 11.4).

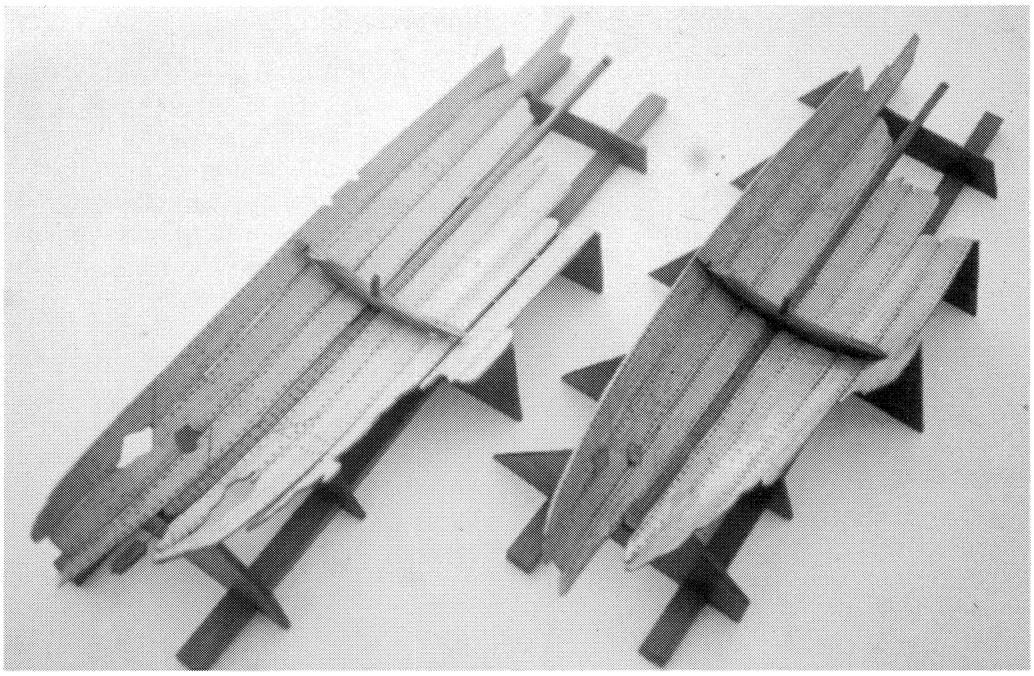

Fig. 11.3. Jules-Verne 9 *shipwreck. Model of archaeological remains (left) and model of remains after reconstruction of the shape (right) (1/10e) (author: R. Roman, Centre Camille Jullian, CNRS).*

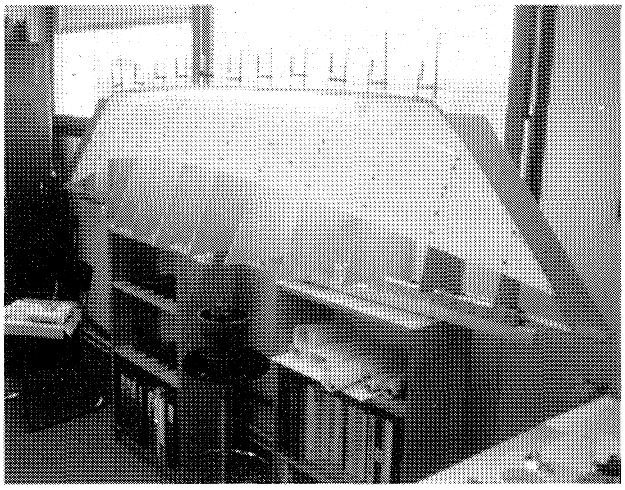

Fig. 11.4. Jules-Verne 7 *shipwreck. Research model for reconstruction of hull lines (1/5e) (author: M. Rival, R. Roman, Centre Camille Jullian, CNRS).*

Reconstruction of structure

Besides the reconstruction study of the hull shapes, study of the structure is essential to reconstruct the ship. It is based on the analysis of archeological remains, either directly by means of the remains themselves that can be extrapolated if necessary, either indirectly by the assembling and fastening marks which are left by elements that have disappeared or which are associated to other remains. Also it may be necessary to utilize comparative elements, once their use is warranted, in order to reconstruct disappeared elements or damaged parts. On a practical point of view, reconstructions always include a first graphic approach which is later checked on the model.

Regarding *Jules-Verne 7* and *9* shipwrecks, it was decided to come back to a 1:10 scale which proved sufficient enough and well fitted to such reconstructions associating shapes and structures (Fig. 11.5).

Reconstruction of superstructure, of propulsion system (rigging and rowing) and of steering device

Although these elements have disappeared and few significant remains have been discovered in these wrecks, it is essential to restitute them in the aim of a total reconstruction of the ships and an assessment of their nautical capacity. The reconstruction of these elements is based on the interpretation of the ship type, its propulsion system, its function and its sailing area. The interpretation depends on the analysis of all the remains taking into account their context and the results of the previous reconstructions. However, due to the small number of archaeological finds, the reconstruction of these elements is chiefly based on comparative data, mostly iconographical. Again warranting of these comparative data is essential in order to avoid any mistake or anachronism.

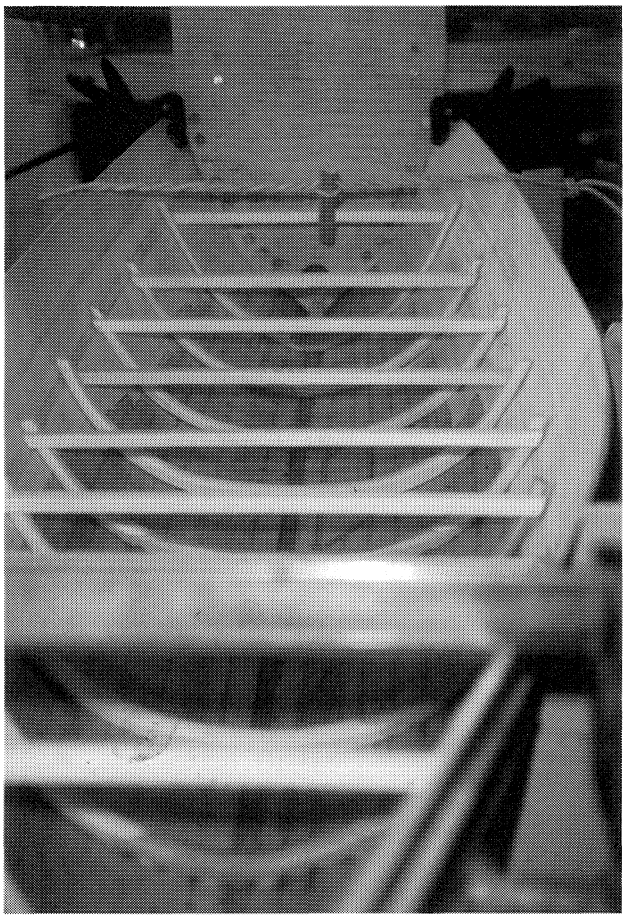

Fig. 11.5. Jules-Verne 7 *shipwreck. Model of reconstruction of the hull structure (1/10e) (author: R. Roman, Centre Camille Jullian, CNRS).*

Regarding both *Jules-Verne 7* and *Jules-Verne 9*, the previous model (shapes and structure) at a 1:10 scale was completed in order to propose a final general reconstruction (Fig. 11.6).

Complementary studies

Outside this reconstruction program, other models may be constructed to answer to other study objectives. Namely, with regard to *Jules-Verne 9* wreck, I would like to recall the life-sized (1:1 scale) study model of a part of the hull including keel, planking, framing intended to replicate experimentally the sewing assembly system (Pomey, 1995: 475, fig. 9). As regard *Jules-Verne 7* wreck, it is worth to report a model of the archaeological remains at a 1:10 scale on which all the independent elements are moving. This model was made in the shipwreck conservation and exhibition program in order to be able to assess the distortions and to evaluate several possibilities of museographical display.

Interpretation

It is obvious that the more important the remains, the more accurate, reliable and close to the original state will be the reconstruction, especially shapes and structure. Also, one could think that reconstructions will be easier when there is a great number of remains. Paradoxically, experience shows quite the reverse; accordingly, work is even more difficult. Indeed, when there is a great number of remains, number of parameters to be integrated in the reconstruction is proportionally higher. That increases constraints and makes the work more difficult chiefly when remains are partial, incomplete and distorted (that would be quite different if the wrecks were almost intact).

Given their state of conservation, *Jules-Verne 7* and *9* wrecks are very different: limited but homogeneous remains for *Jules-Verne 9*; reasonably complete but broken remains for *Jules-Verne 7* (Pomey, 1995, 1998).

Jules-Verne 7 wreck

Remains are preserved over 14 m in length and 4 m in width. There is a great number of breakings and distortions. Framing is scattered. However, the part of which elements may be connected represent about 2/3 of hull significant elements. Namely keel is entire and the starboard side is conserved up to the third wale. Many strakes are entire on both sides and many frames or intermediate top timbers are preserved up to their outer end. On the other hand, stem-post, stern-post, mast-step timber and upper parts have disappeared.

Reconstruction of forms

Besides correcting of distortions, main difficulties encountered involves the reconstruction of the keel line, cross-sections and asymmetry of the hull planking. As regard the keel, analysis of the foot of floor-timbers with diverse angles showed that keel was slightly rockered. Comparison with Ma'agan Mikhaël wreck (Kahanov, 1998) which although later belongs to the same ship family and to the same shipbuilding tradition (Pomey, 1997a) made it possible to estimate the rocker. As regard cross-sections, difficulty involved the dispersal of framing of which no element was in place. However, matching of nailing points and passage holes reflecting strake edges, both on frames and planking, made it possible to set in place fourteen elements of frames (of twenty-four which correspond to fifteen reconstructed frames and to the corresponding intermediate top timbers) distributed between the center, the master frame area and the extremities. As regard asymmetry of hull planking, building up the model made it possible to confirm on the starboard side the presence of inserted stealers (strake 6bis) which were assigned to closing of the hull at each extremity. On the other hand, in spite of the lack of stem-post and stern-

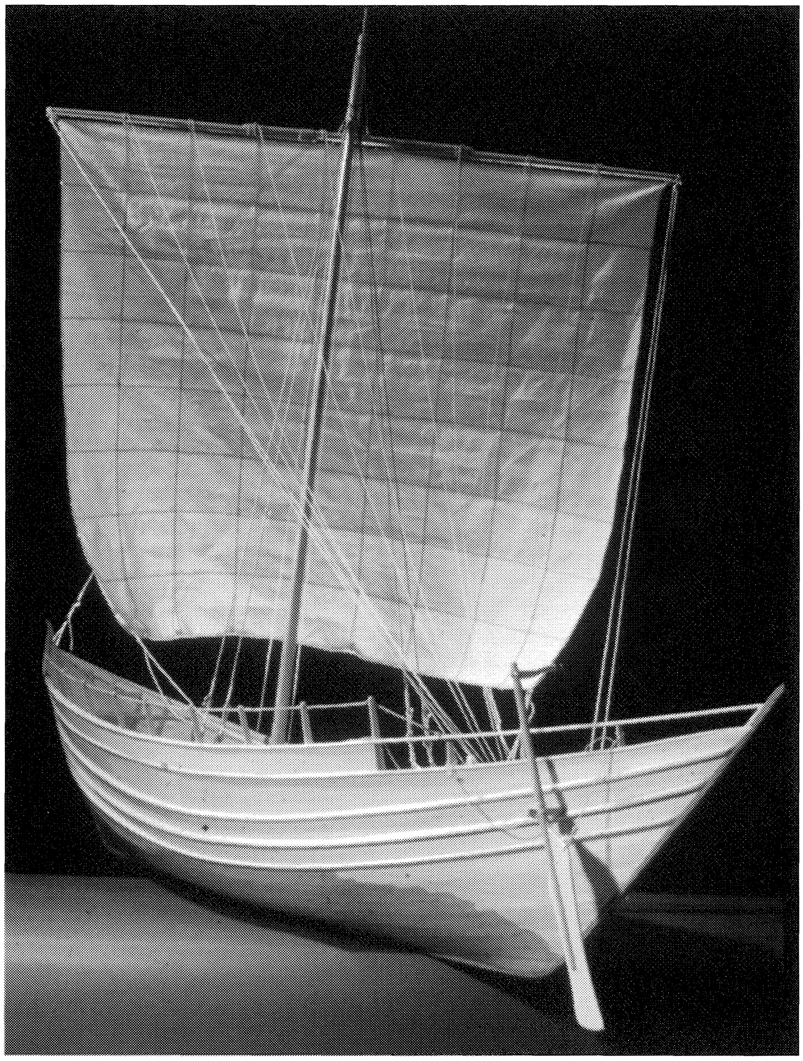

Fig. 11.6. Jules-Verne 7 *shipwreck. Final model of reconstruction of the whole ship (1/10e) (author: R. Roman, Centre Camille Jullian, CNRS).*

post, they could have been reconstructed accurately by means of well preserved extremities of the keel and the first strakes, and of the joinery of an extremity of the upper wale. Also, width and height could be assessed accurately thanks to many complete frames which had at their upper end the joinery with transverse beams and thanks to several intermediate top timbers inserted between frames and conserved up to the sheer line. A stanchion totally preserved made it possible to check how right was the reconstruction of transverse beams.

Reconstruction of structure

On one hand, most important part of the structure could be directly reconstructed either from preserved elements (keel, strakes and wales, frames and top timbers, stanchion), either by deducting them from their joinery marks (stem-post, stern-post, transverse beams, gunwale...) (Fig. 11.7). On the other hand, as regard reconstruction of mast-step timber which was inferred from joinery elements with keel, it was decided to use as a model that from Gela wreck (Panvini, 2001) whose type was similar and slightly contemporaneous (Pomey, 1997a). Moreover, the Gela wreck had exactly the same joinery between the mast-step timber and the keel. In addition to that, a lateral partner of the mast hole made it possible to reconstruct its structure (Fig. 11.8).

Reconstruction of superstructure, of rigging and of steering device

On one hand, a part of hull superstructure, in particular bulwarks, wash-boards, rails and rudder were reconstructed from iconographical data because of the lack of archeo-

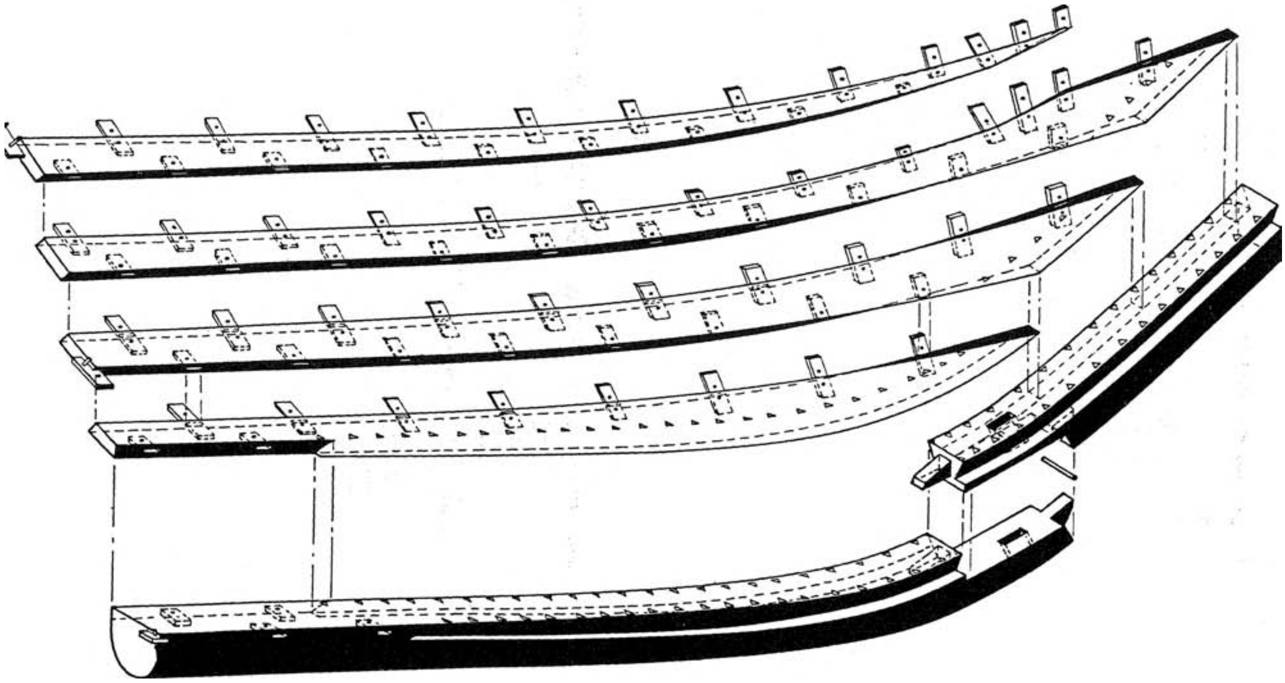

Fig. 11.7. Jules-Verne 7 *shipwreck. Axonometric reconstruction of the stem-post (drawing: M. Rival, Centre Camille Jullian, CNRS).*

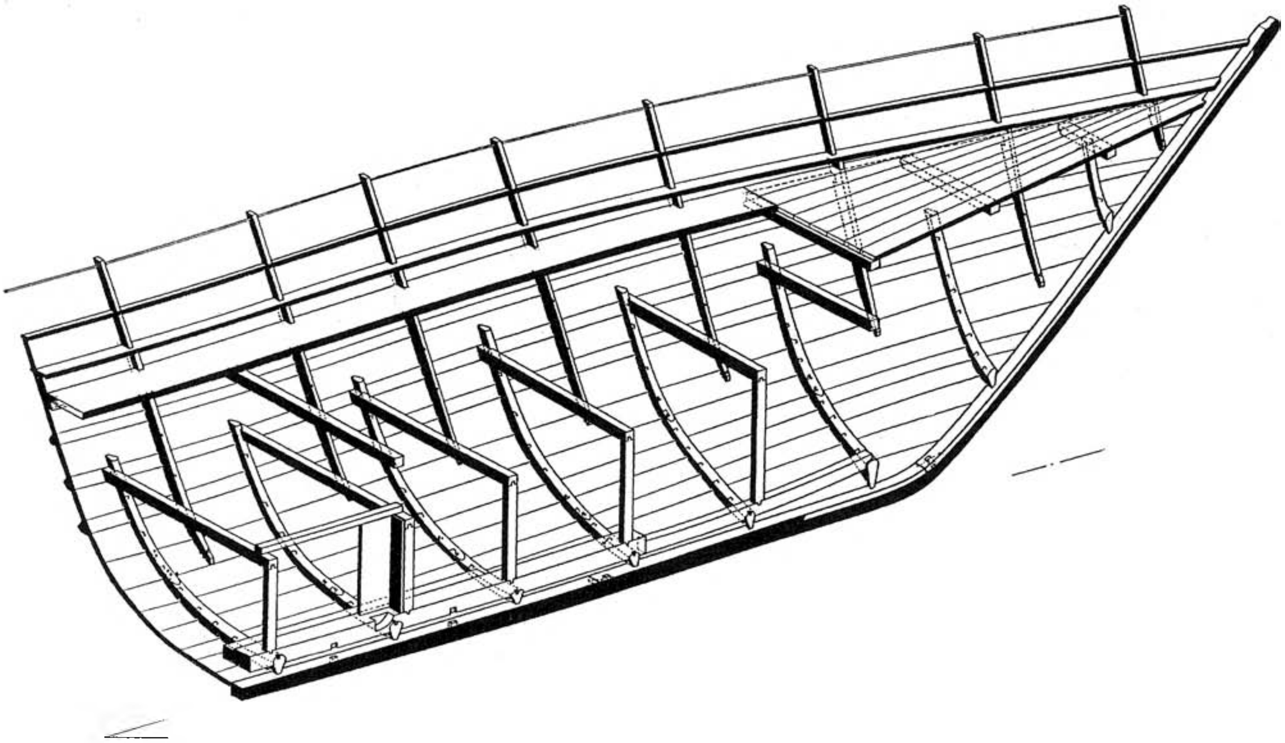

Fig. 11.8. Epave Jules-Verne 7. *Axonometric reconstruction of the structure of the fore part of the ship with mast-step timber (drawing: M. Rival, Centre Camille Jullian, CNRS).*

logical data (Fig. 11.9). The attic black-figure cup of the London British Museum (B. 436) (Morrison, Williams, 1968: 109, pl. 19; Pomey, 1997b: 49, 79) dated *ca.* 510 BC that represents twice a merchant ship under sail assaulted by a pirate oared-ship was used as a reference. Its same date than the Place Jules-Verne wrecks and its quality made a unique document for that period out of it. On the other hand, fore deck and after deck and gangways are very likely hypotheses deduced from Kyrenia II that is the sailing replica of the Kyrenia wreck (Katzev, Katzev, 1989).

Characteristics

As a whole, restitution of *Jules-Verne 7* wreck is that of a little merchant ship, a sailing coaster, having circum-Mediterranean capacities. Its main dimensions are: length (between perpendiculars) 15.65 m; breadth (main beam) 3.80 m; depth 1.70 m; its deadweight capacity is about 11 metric tons for a load displacement about 15 tons.

Jules-Verne 9 wreck

The wreck is preserved over 5 m in length and only 1.40 m in width in a part involving the hull bottom and located between an extremity and the center. Only is a floor-timber in place on which the bottom of a stanchion is visible. Nevertheless, the whole is rather homogeneous.

Reconstructions of shapes

Given the state of conservation of the wreck, this reconstruction necessitated several hypotheses on the initial ship dimensions and the shapes of her extremities. These hypotheses were formulated from *Villeneuve-Bargemon 1* wreck that was discovered close to place Jules-Verne in a similar archaeological context to *Jules-Verne 9* wreck and that is typologically[4] similar to *Jules-Verne 9* wreck. Hypotheses were also formulated from the *Golo* wreck (Corsica), that is an older discovery (Pâris, 1882–1892; Basch, 1973) and whose characteristics allow to interpret it as a ship of same type and same tradition (Pomey, 1997a). The former is of interest as its keel is entirely preserved and its extremities of strakes make it possible to assess curvature of one extremity. The latter offers the advantage to be exceptionally preserved in any part. It has a symmetrical hull whose example was followed for studying of *Jules-Verne 9* wreck.

Reconstruction of structure (Fig. 11.10)

In addition to the only floor-timber in place with its stanchion, marks left by frames on the bottom of the hull and an isolated remain interpreted as an intermediate top timber allow to reconstruct a frame structure identical to that of *Jules-Verne 7* ship. Moreover, similarity between *Jules-Verne 9* and *Bon Porté 1* wrecks naturally leads to use the latter to achieve reconstruction, especially for the small mast-step timber that is also present in the *Golo* wreck.

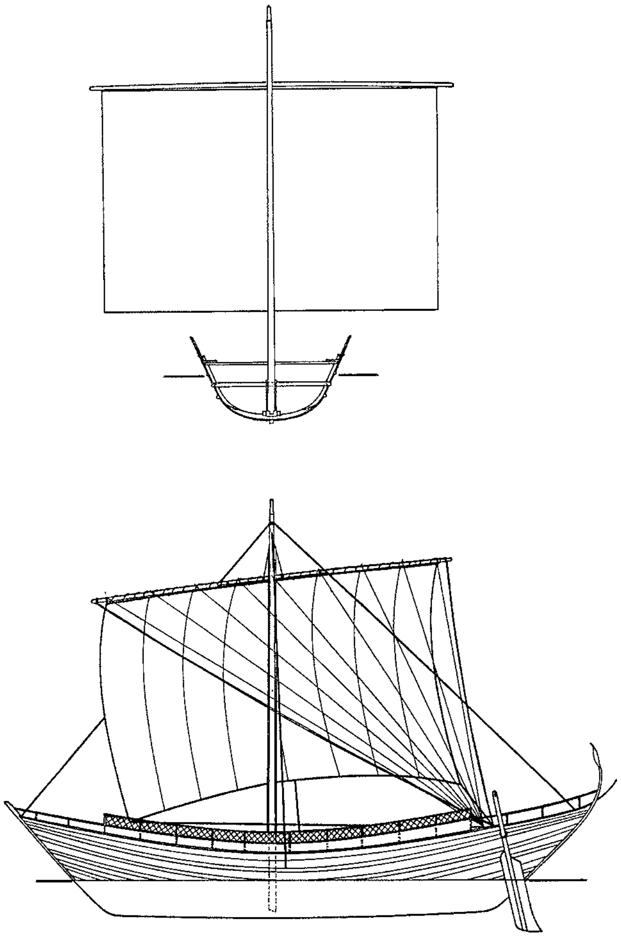

Fig. 11.9. Epave Jules-Verne 7. *Drawing reconstruction of the ship under sail (cross section and side view) (drawing: M. Rival, Centre Camille Jullian, CNRS).*

Reconstruction of superstructure, of propulsion system and of steering device

Again, reconstructions stay hypothetical since they are drawn from solutions adopted for *Jules-Verne 7* wreck. A small foredeck is attested on the *Golo* wreck. As regard an auxiliary sail it is deduced from reconstructing of a mast-step as for *Bon Porté 1* and the *Golo* wrecks. However, the ship type probably devoted to coastal fishing as attested by little bits of red coral found in the wreck (Pomey, 2000), its dimensions and its lightness, all assign it a main oared-propulsion.

Characteristics

A light and fast ship devoted to oar-propelled coastal fishing and sailing and provided with an auxiliary sail

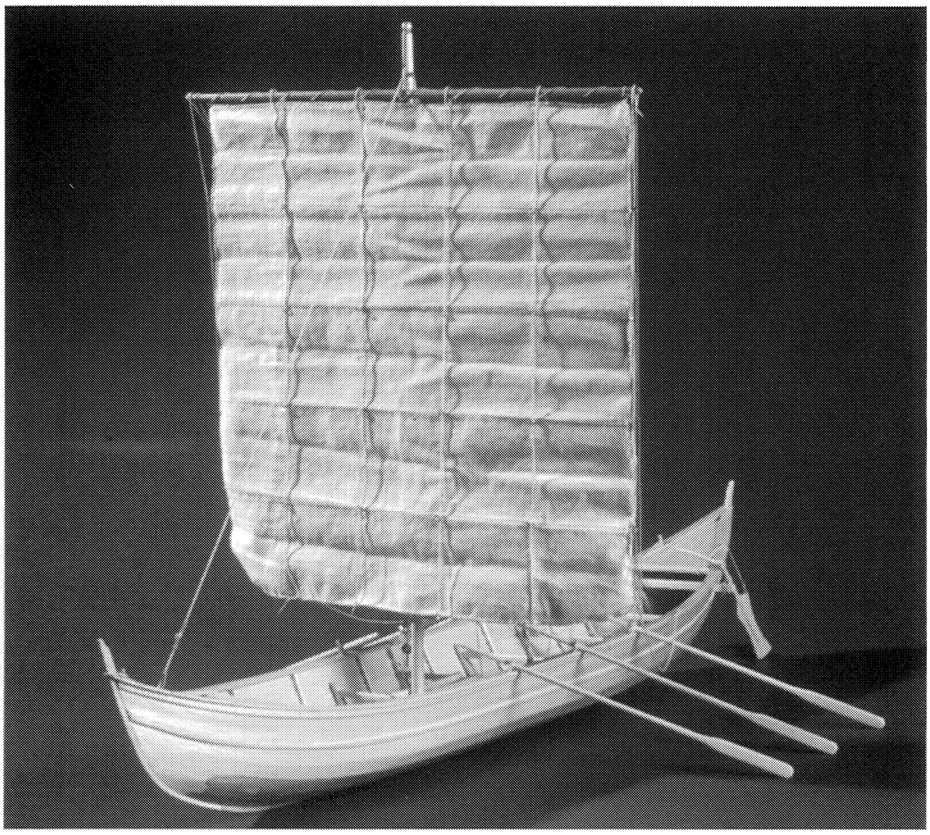

Fig. 11.10. Epave Jules-Verne 9. *Final model of reconstruction of the whole ship (1/10e) (author: R. Roman, Centre Camille Jullian, CNRS).*

results from the reconstruction of *Jules-Verne 9* wreck. Its main dimensions are: length (between perpendiculars) 9.50 m; breadth (main beam) 1.88 m; depth 0.75 m; its deadweight capacity is about 2 metric tons for a load displacement about 3 tons.

Conclusions

As a summary of these reconstructions, three levels may be considered:

- *sure reconstructions*; they are obtained from archaeological remains, either directly from archaeological remains, either indirectly from assembly and fastening marks from elements that have disappeared, *i.e. Jules-Verne 7* stem-post and stern-post, frames, transverse beams, ...
- *probable reconstructions*: these are inferred from comparative data mostly representative of contemporaneous and same type and same tradition shipwrecks, *i.e.* mast-step;
- *possible reconstructions*: they are proposed as hypotheses from archaeological, iconographical or ethnographical comparative documents, *i.e.* superstructure, rigging, steering gear.

Notes

[1] Both shipwrecks were submitted for conservation treatment to ARC-Nucléart laboratory in Grenoble. *Jules-Verne 9* wreck is already treated and is being in display in the Musée d'Histoire de Marseille. *Jules-Verne 7* wreck is still being treated.

[2] This program I supervised was carried out with the support of Michel Rival who achieved drawings and graphic reconstructions and Robert Roman who made the models.

[3] Photogrammetrical drawings were carried out by Société d'Etudes et de Travaux Photogrammétriques, Salon-de-Provence (France).

[4] This wreck is also called *César 1* (Pomey, 2001). The wreck was discovered in 1997 during the Place Villeneuve-Bargemon excavation, this place bordering the Place Jules-Verne in Marseille (Hesnard, 1999: 18, 34).

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12. The Late-Roman *Fiumicino 1* Wreck: Reconstructing the Hull

Giulia Boetto

Introduction

The reconstruction of the Late-Roman *Fiumicino 1* ship started in the Centre for Maritime Archaeology of Roskilde (Denmark) in 1997.[1] Two years later, the research was continued in the Laboratoire d'Archéologie Navale of the Centre Camille Jullian at Aix-en-Provence (France). The first part of the project was funded by the CMA of Roskilde, the latter by the Italian CNR (National Center of Research) and the CCJ. The goal of this research has been the preparation of a line drawing controlled by means of one or more research models.[2]

Fiumicino 1

Fiumicino 1 wreck came to light in 1959 during the construction of the airport Leonardo da Vinci at Fiumicino (Rome). The excavation provided the opportunity to uncover the remains of four other wrecks: *Fiumicino 2*, the "sister ship" of *Fiumicino 1*; *Fiumicino 3* and *Fiumicino 4*, two medium size vessels; and *Fiumicino 5*, a small fishing boat. These ships were abandoned in a veritable "naval cemetery" (Boetto, 1998; 2001) set in a peripheral area of the harbour built by the emperor Claudius in 42 AD.[3]

Fiumicino 1 is a flat bottomed ship (Fig. 12.1). The wreck extends from sternpost to stem for a length of 13.83 m. The starboard side from the middle body forward is 1.47 m high, while the remaining part and the port side are broken along the bilge. The maximum breadth surviving is 4.57 m.

The results of the re-investigation of this vessel were presented in Gdańsk at ISBSA 8 (Boetto, 2000), but on this present occasion it seems necessary to mention some of the details again.

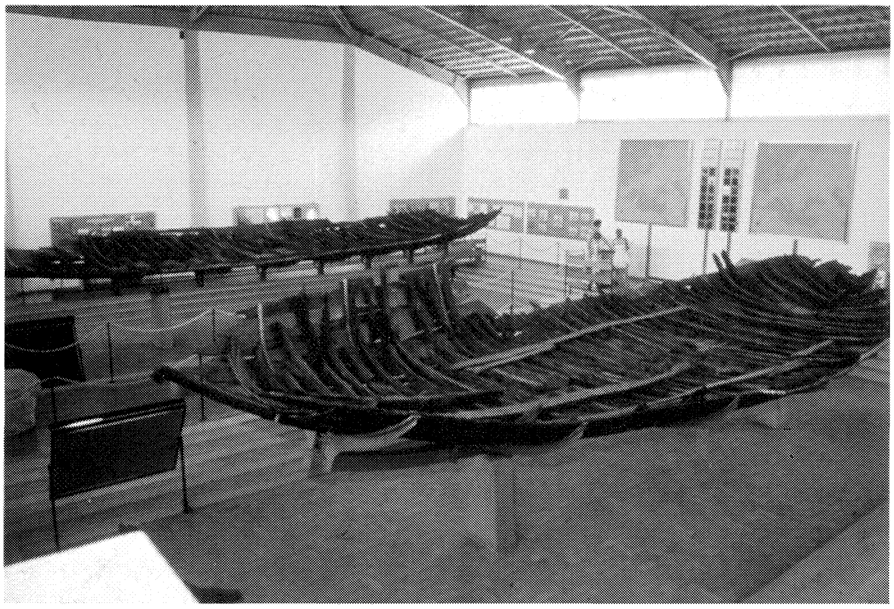

Fig. 12.1: Fiumicino 1 *in the Museum of the Ship (courtesy: Archaeological Superintendency of Ostia)*

New observations about the ancient system of construction allowed us to suggest that the ship should be dated between the 4th and the 5th centuries, and that it was built shell-first.

However, we also recorded some "skeleton-first" construction features. They were:

- floor-timbers bolted to the keel;
- unpegged tenons;
- transverse iron nails connecting garboards to the keel;
- looseness of tenons.

We connected these characteristics with the long life of this river barge, which suffered numerous repairs and replacements (for example, the keel and some planks at stern). These replacements were intended to strengthen the general structure of the hull.

Finally, one of the most important results of the study of *Fiumicino 1* was its identification as a particular type of vessel used to transport the merchandise, trans-shipped from the large maritime cargo vessels, from the imperial ports up to Rome, along the Tiber.

In particular, thanks to the re-investigation of the wreck, the keelson was placed in its original position, much further forward of the centre of gravity, in the fore part of the vessel. So we could hypothesize the very simple recess of the keelson, with an internal slide to lower the mast, was used to step a towing-mast.

Since these constructive characteristics belong to a fluvio-portual vessel, the general structure of the hull, which is flat-bottomed with a curved stern, the elongated stem and the towing-mast well-forward, led us believe that *Fiumicino 1* could be a special kind of vessel known from ancient sources as a *navis caudicaria*, a vessel which was towed from the right bank of the river.

Several pictorial representations, dated from the 2nd to the 4th century AD, present an image of this family of ships. The *Isis Geminiana* fresco from Ostia and now in the Vatican museum, the *Piazzale delle Corporazioni* mosaic in Ostia, the cippus in the *Museo Nazionale Romano* and the relief in the *Salerno* cathedral, show some common characteristics: a rounded hull at the stern, an elongated stem, a mast stepped forward with cleats and without sail, the tow line fastened to a bollard on the mast and towing posts or a little support at the gunwale, the side rudder, a deck and a stern cabin (Casson, 1965).

The lines

Interpretation of the *Fiumicino 1* ship did not begin with the start of excavation. The site plan of the vessel and descriptive catalogues of the structures were not produced forty years ago. Only after the recovery of the wreck and after its conservation, the documentation of the ship was prepared. The lack of first-hand documentation is one of the most important limits of our study.

The vessel has been distorted, some of its planks and frames have been cracked. However, we decided to use the available graphic documentation – a German photogrammetry made in 1976 (Scrinari, 1979: Fig. 16) – in order to produce the lines of the ship.

At that time, the sections were produced from the exterior. Consequently, our reconstruction concerns the outer surface of the shell while, normally, the lines describe the inner surface related to the frame.

In *Fiumicino 1*, the transverse sections were spaced at 25 cm. The given graphic was not so clear: on the paper it is very difficult to distinguish each section.

In Denmark, we used all the sections. Later, we decided to use only eighteen of them. We tried to have these sections near to the frames in order to control the shape of the outer shell using the internal curvature of the timbers which had already been recorded from inside the hull.

On the longitudinal section, the central part of the keel has been assumed to be flat. Then, it has been prolonged following the curvature of the ends. However, a bend in the keel is visible on the plan, which makes it difficult to locate the centerline.

In the first line drawing, we aligned the sections along the port side of the keel. As this was not satisfactory, for the second set of lines we calculated the centreline of each section with a simple graphic process. From a line drawn at the base of the keel, we drew a perpendicular through the keel centre (Roman, 1997). Each section was then rectified by extrapolation of a line tangential to the outer surface of the planking.

To reconstruct the original dimension of the vessel, we followed a method used, for the first time, in the reconstruction of the lines of the *Madrague de Giens* wreck (Pomey, 1982). Illustrations depicting a *navis caudicaria* were measured and the proportions between the principal dimensions calculated. The average values was then used to estimate the proportions of *Fiumicino 1* which is a vessel 17.18 m long, 2.40 m high to the deck and 5.60 m wide.

Finally, representational evidence, in particular the *Salerno* relief, was used to reconstruct those parts of the wreck which had not survived (Fig. 12.2, above the dashed lines).

The model

The three-dimensional research continued with the construction of a 1:10 scale model. Each transverse section was assumed to be symmetrical about the centreline. Sections were cut in plywood (Fig. 12.3) and assembled on an alluminium rail at the given interval. This mould model was then used to determine the planking shapes (Fig. 12.4).

The width of each plank was produced from the plan and from direct measurements along each frame. The distorted planks, for example in the fore part of the ship,

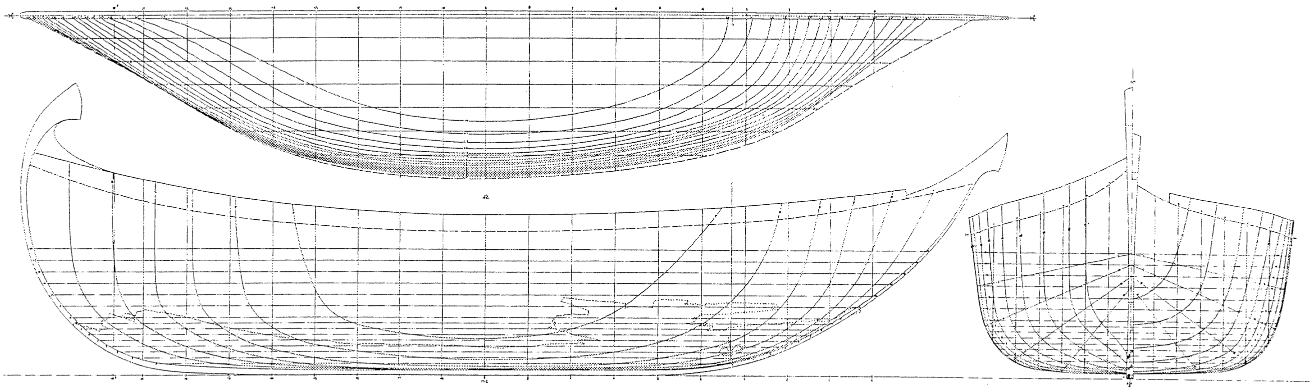

Fig. 12.2: Fiumicino 1*: the lines drawing.*

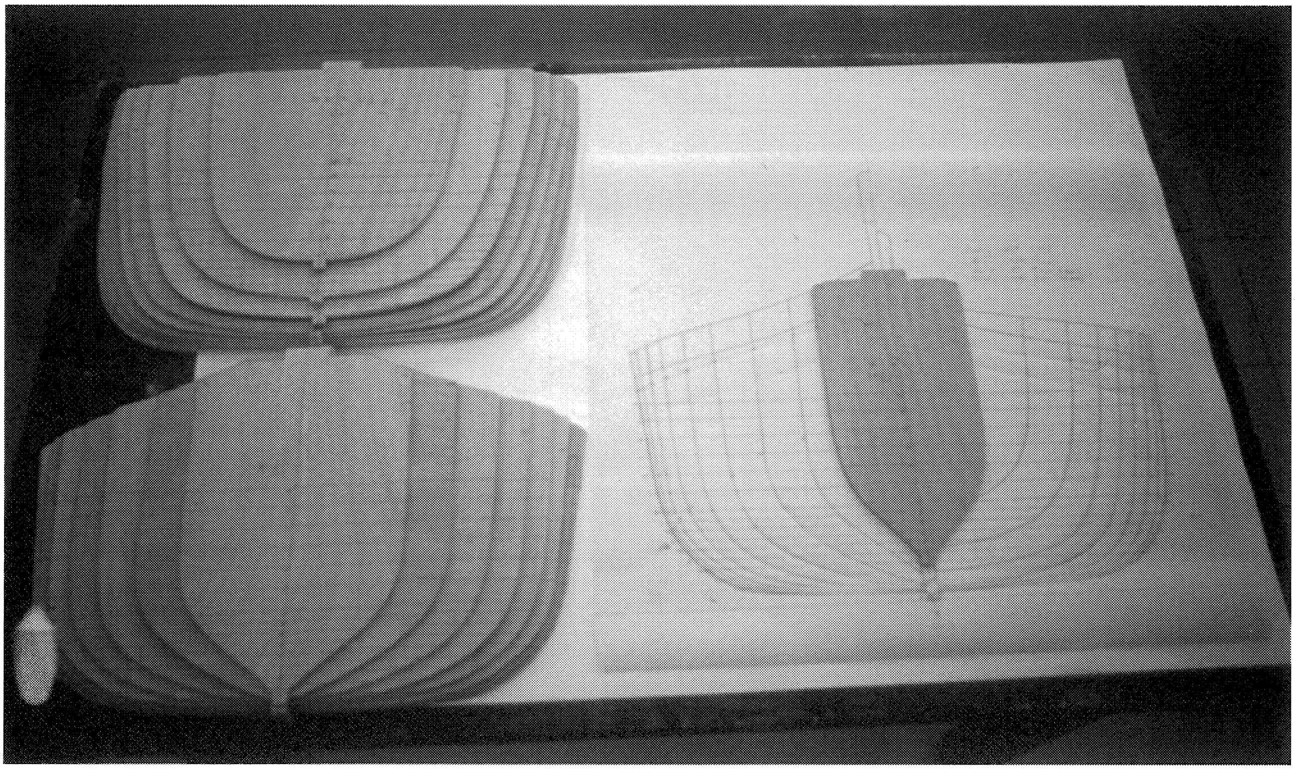

Fig. 12.3: Fiumicino 1*: the transverse sections cut in plywood.*

were rectified and radial shrinkage allowed for.

The planks were made in pasteboard. The model was very useful for establishing the shape of the planking in the fore part, as the archaeological remains there are not well preserved. At first, we obtained very long and pointed planks. In view of their structural weakness, these planks have been alternated with scarfs to obtain larger butts on the keel (Fig. 12.5).

Conclusions

This research model of *Fiumicino 1* has been the basis from which a display model of the vessel was built (Fig. 12.6). The work was pursued in the model workshop of the Museum für Antike Shiffahrt at Mainz (Germany) within an agreement with the Archaeological Superintendency of Ostia.[4]

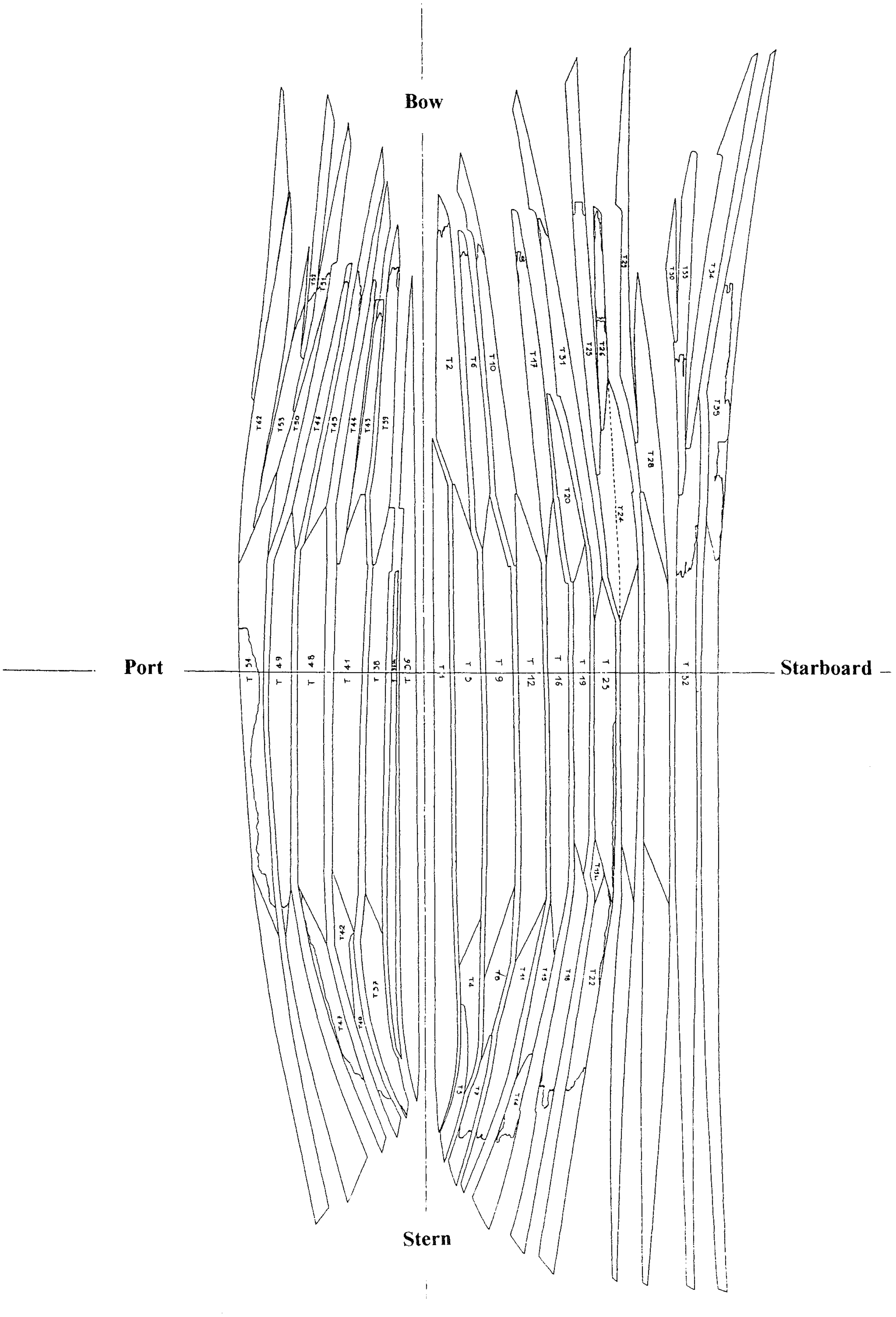
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Fig. 12.4: Fiumicino 1*: plan of the planking.*

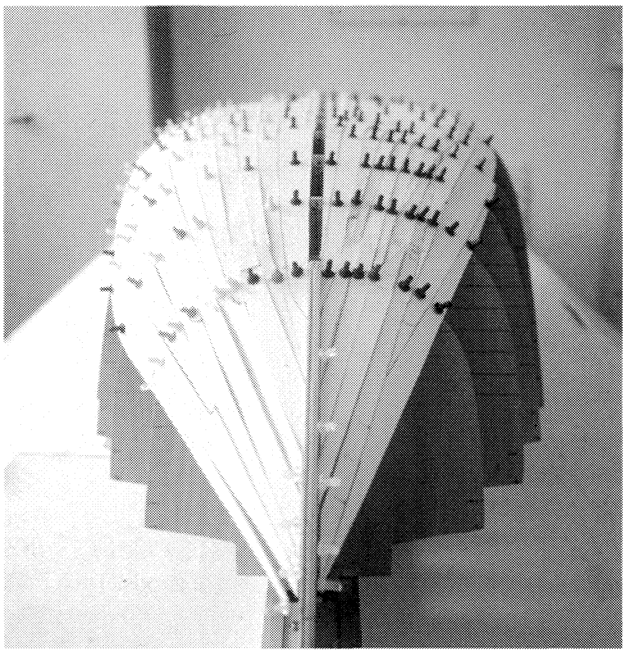

Fig. 12.5: Fiumicino 1*: the bow of the research model.*

Notes

[1] The preliminary line drawing, prepared in collaboration with Sune Villum-Nielsen (NMF), was used by Ken Jensen (1999) for calculate dimensions, hydrostatic data and coefficients (catalogue n. B8–B9).

[2] The method followed is inspired by the "Steffy method" (Steffy, 1994: 214–228) and the work was undertaken in collaboration with Robert Roman and under the supervision of Patrice Pomey (CCJ).

[3] On the port of Rome see: Verduchi, 2001 with references.

[4] This display model was presented in the naval section of the exposition "*Ostie, port de la Rome Antique*" held in Geneva (Switzerland) in 2001 (Descoeudres, 2001).

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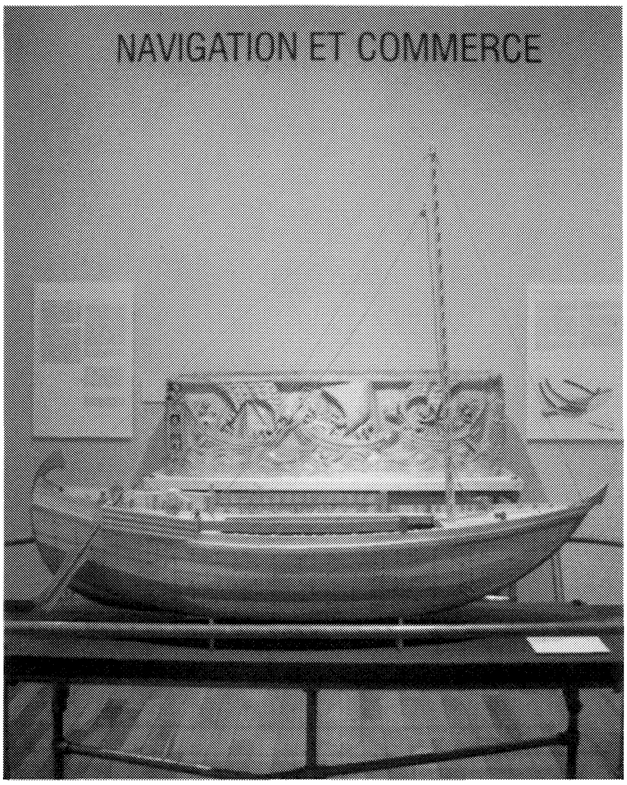

Fig. 12.6: Fiumicino 1*: the display model in the Geneva exposition.*

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13. The Reconstruction of the *Ladby* Ship – Using a Working Spline Model and Computer

Vibeke Bischoff

Denmark's best-known ship-grave from the Viking Age, at Ladby near Kerteminde on the island of Funen, was found in 1934 by Poul Helweg Mikkelsen, an amateur archaeologist and pharmacist from Odense. The mound is situated near the Kerteminde Fjord (Fig. 13.1).

The ship and its contents were excavated in the course of the two following years under the direction of Gustav Rosenberg, a conservator at the National Museum in Denmark. Of the actual ship there was virtually no wood left, except some remains of a few frames, but its shape and construction were apparent from the approximately 2000 or so rivets and nails which remained in the clay and sandy soil. The ship had been used for the burial of a distinguished man, to judge by the grave goods. The grave goods included weapons (arrowheads and a shield umbo), table ware (a bronze platter, a silver plate, a bucket) and riding equipment (bridles, stirrups and a spur). Fragments of all these objects were found in the stern part of the ship, and in the forepart the skeletons were found of eleven horses and four dogs. The ship-grave dates to the first quarter of the 10th century AD, due to the artefact types and their decoration (Sørensen, 2001).

During the excavation, all nails and rivets were measured in three dimensions using a levelling instrument and each

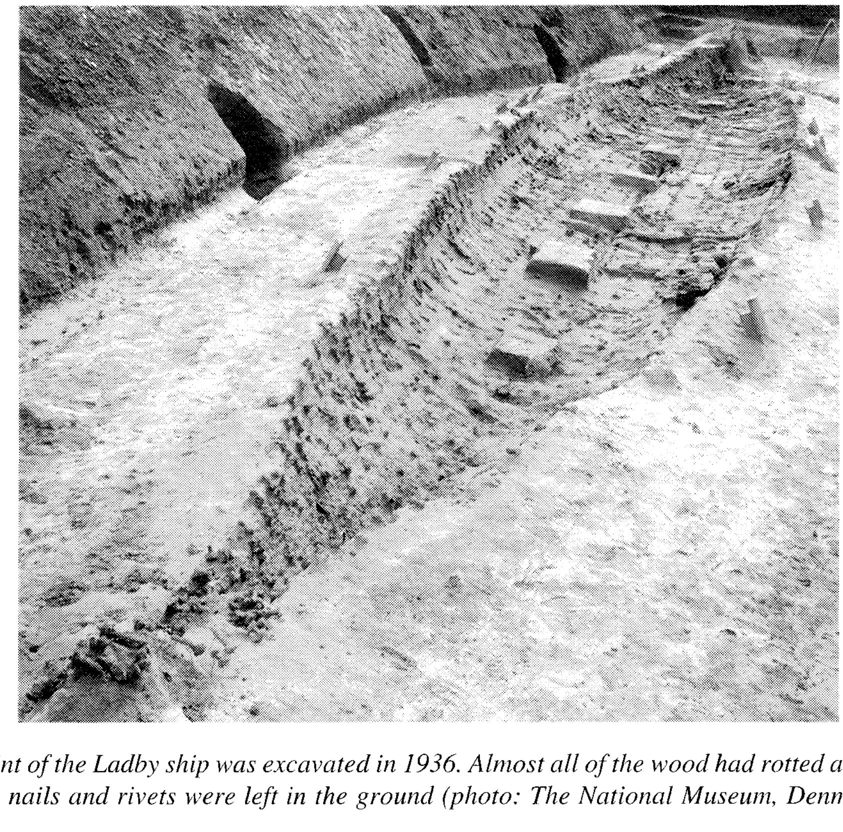

Fig. 13.1. The imprint of the Ladby ship was excavated in 1936. Almost all of the wood had rotted away, but almost 2000 iron nails and rivets were left in the ground (photo: The National Museum, Denmark).

was given a number. Many photographs were taken of the imprint and all the nails and rivets were thoroughly examined and described in notebooks and excavation diaries. After the excavation, a concrete vault was built over the ship imprint and the burial mound was recreated on top of this.

In 1948, after the death of Gustav Rosenberg, Knud Thorvildsen from the National Museum was asked to publish the work. In order to do so Thorvildsen re-examined the find, and made some new important observations and measurements (Thorvildsen, 1957). In connection with remains from frames, he found two long nails in each side of the ship used for fastening the top ends of the floor timbers to the third and the fourth strake. By finding these long nails in the full length of the imprint, he was able to reveal the distance between the frames. In order to make drawings of the ship he then documented the imprint manually, by measuring the rivet lines at the positions of the frames throughout the ship. The cross sections he measured were of great importance for the reconstruction of the ship 50 years later.

At the end of 1993, the National Museum's Centre for Maritime Archaeology in Roskilde embarked on a re-evaluation of the ship-grave from Ladby. This included an attempt to produce a new and up-to-date reconstruction of the ship (Bischoff, Jensen, 2001). A reconstruction of this type requires information about the shape of the hull that is indicated by the position of the nails, and the construction that is indicated by the length and type of the nails and the wooden remains.

The difficulties of reconstructing the original appearance of the ship were rapidly recognised as being a large undertaking. Taking into account the nature of the find, it was therefore decided to resort to unusual methods. Normally, reconstructions of ships are built using manual craft methods exclusively, but in this case, an experiment was attempted using a combination of an advanced working model and computer-generated visual-imaging.

Reconstruction of the ship as a spline model

The Ladby ship was a long, narrow warship, about 21.5 m in length and with space for 30 oarsmen. It had been painted blue and yellow and decorated with a dragon-head and tail. From study of the excavation reports, the note books, diaries, photographs, drawings and the impression itself as it stands today, we can gain a certain amount of knowledge of the ship's construction. The frame spacing was about 90 cm. This is known both from the remains of wood from some of the frames, and from the long nails in the third and the fourth strakes used for fastening the top ends of the frames. The rivets belonging to the fourth strake were about 8–9 cm long in the top of the strake and 6–7 cm long at the bottom showing that the fourth strake was a very substantial board, about 5 cm thick at the top and about 3 cm below. We also know that the ship had a mast, placed slightly forward of centre, supported by shrouds to four shroud-rings on each side. Seven of these shroud-rings were found during the excavation indicating the approximate position of the mast. The shape of the hull, the breadth and thickness of the planks, joints, etc. are understood by studying the material more closely.

In order to work with the hull-shape in a precise and manageable way, a specially-built, adjustable spline model consisting of movable battens in scale 1:10 was made (Figs. 13.2–13.3). The model consisted of 18 templates that were adjustable both vertically and horizontally. The templates were constructed with a ruler lying horizontally above. Fixed between this ruler, and a wooden runner, aluminium sticks, one for each strake, came vertically down. At the end of each stick was fitted a small metal eye for the positioning of a batten of perspex that ran the length of the ship and formed the rivet lines. The sticks can be individually moved both horizontally and vertically making it possible to adjust the cross-sections. The ruler above makes it possible to read the lateral measurement for each rivet-line. Along the sides the templates are fixed in place between two aluminium top-fixtures and can be moved up or down individually in order to make length-wise adjustments if hogging has to be corrected.

The templates were designed from Thorvildsens's cross-section drawings from 1948. The reason for using these was that Thorvildsen measured the rivet-lines and their relations to the planks. This cannot be obtained directly from the computer generated plan of the nails and rivets because the cross sections were made by cutting slices of 20 cm out of the cloud of dots to get enough data to make a cross section. These cross sections showed the shape of the imprint and all the nails and rivets in the area. It was impossible to distinguish which rivets were belonged to which strake. In order to see if the measurements from

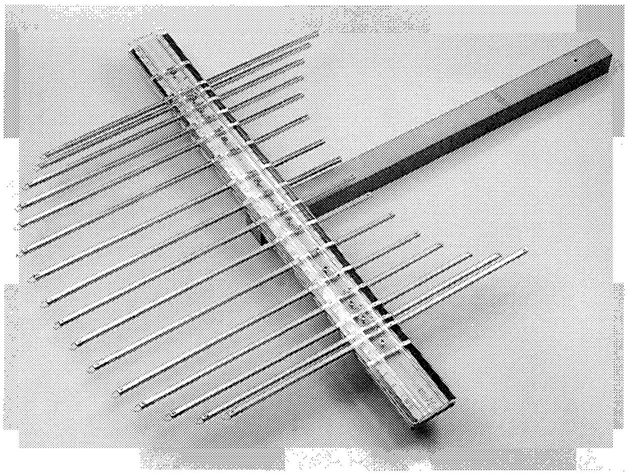

Fig. 13.2. The specially-produced template enables adjustment of the spline model both vertically and horizontally to provide a sound basis for determining the lines of the Ladby ship (photo: W. Karrasch, The Viking Ship Museum).

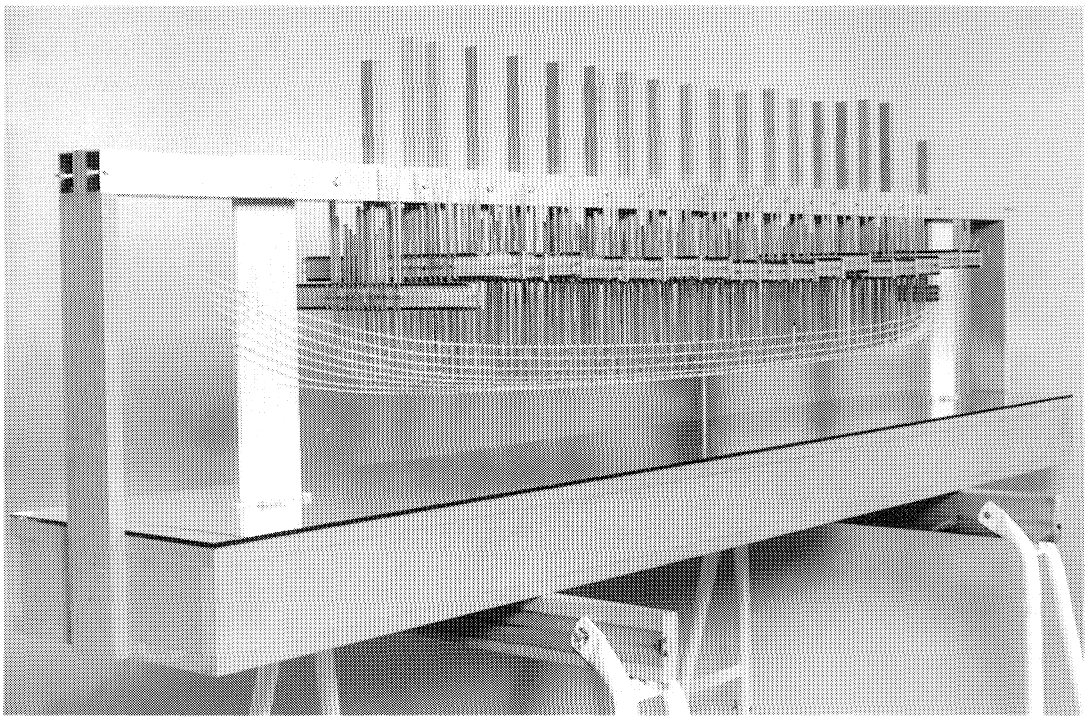

Fig. 13.3. The spline model made for reconstruction of the rivet lines of the Ladby ship (photo: W. Karrasch, The Viking Ship Museum).

1936 and 1948 could also be used, cross-sections from the plan of the nails and rivets was superimposed on top of Thorvildsens cross-sections. Thorvildsens measurements proved to be in accordance with the nail and rivet plan.

The first positioning of the model reflected the find-situation in 1936, and this made it possible to gain an overall impression of what had happened to the ship after its deposition. The hull's upper-most planks and the bow had collapsed. The starboard side from the centre forward had also collapsed. Since the ship is symmetrical from the aft stem to the midship area, this means that the foremost starboard side had fallen outward without this affecting the port side. This positioning also showed that the ship had hogged, *i.e.* the keel curved upwards in the middle. This hogging can only have occurred before or at the time when the ship was covered with soil, and not as a later consequence of the ship being in the mound. The shape of the keel described a regular concave arch, and the nail-lines in the bottom corresponded exactly. This implies that the ship was in one coherent unit when the hogging occurred. In order to reconstruct the correct shape of the keel, a thin and flexible model, scale1:10, of the hogged keel was made. It was then supported at the two deepest points, and when pressure was applied at one particular point on the keel a regular convex arch was created, forming a realistic keel-line. The templates in the model-construction were then adjusted so that the cross-sections matched the new keel-line.

The next question was to find out what the stems had looked like. The first reconstruction drawing which Thorvildsen made had a rabbeted stem like the Gokstad, Oseberg and Nydam ships, as those ships were the only basis for comparison available to Thorvildsen. If the ship had had a rabbeted stem, nails would have been used to fix the boards to the stem. This was not in fact the case; on the contrary, the planks seem to have had rivets at the ends. On the basis of a print of the port side of the after stem, and by carefully studying all the nails, a picture was evolved of a stepped stem with the lines of the three lowest hood-ends and a junction between the keel and the after stem. Above this join, the nails for fastening the garboard to the keel was visible (Fig. 13.4). The drawing of the after stem was then transferred to the spline model, and the battens were brought forward to fit with the line of the stern. The fore stem was very deformed and could therefore only be adjusted on the pattern of the after stem.

Before the adjustments to the rivet-lines were made, a mirror was placed below the battens, so that the whole structure was visible (Fig. 13.5). It turned out that the uneven rivet-lines only had to be adjusted 2–3 mm, in order to make the lines fair.

The breadth and inclination of the seventh plank required evaluation. The plank had fallen down and was sagging in the middle, which meant that it needed extensive adjustment. During the excavation they did not find any traces of an eighth strake, since there were no iron nails sitting

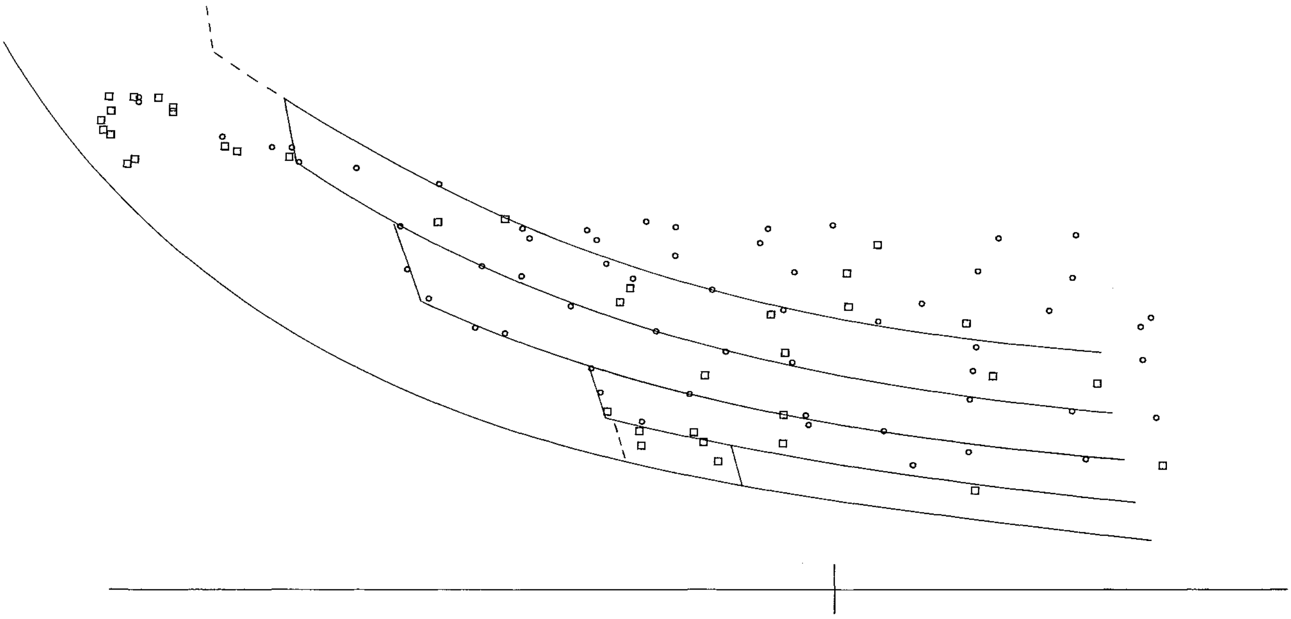

Fig 13.4. A print of the port side of the after stem, where the first three strakes and the scarf between the keel and the stem are drawn in. The ship had a stepped stem!

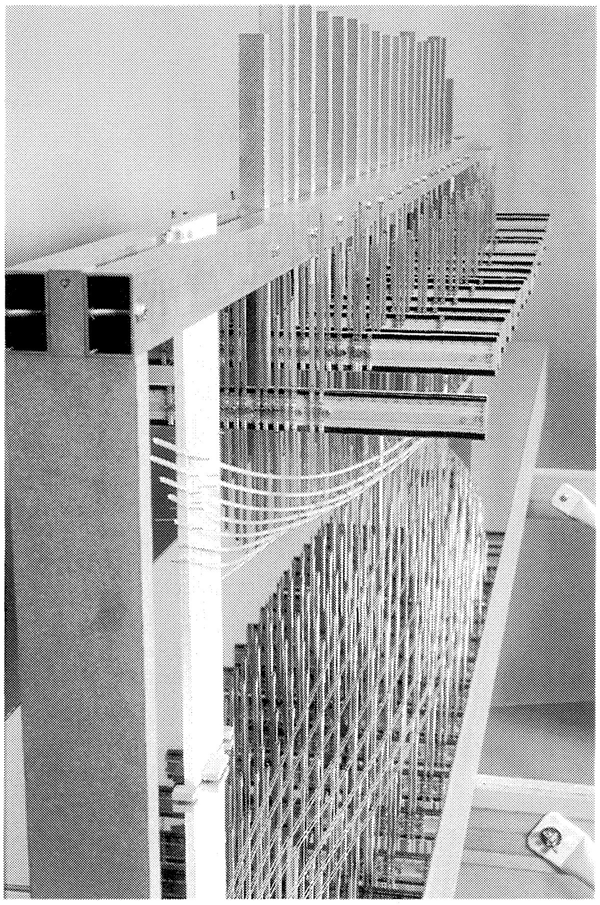

Fig. 13.5. A mirror was placed under the model-display to improve the view of the lines. (photo: W. Karrasch, The Viking Ship Museum)

on top of it. If there had been any faint traces of wood left it was dug away during the excavation, since it was the line of the nails they were following in the beginning. There are several indications, however, that it had existed. In one particular place during the excavation, wood was found some 3–4 cm above the uppermost nails, and that must have been the remains of the eighth strake. But this was at the time not regarded as an eight strake since the uppermost row of nails, which was the first nail line to be dug out was regarded as the top of the ship. The uppermost row of nails consisted of 6 cm-long nails at a distance of 22–25 cm. This is the same spacing as the rivets in all the other strakes, indicating that these nails had been used for fastening an eighth strake. The strake had probably been nailed to a stringer, as has been seen on *Skuldelev 3* and *5*. Finally, the ship's sides would in fact have been too low without an eighth strake.

From excavation diaries to computer model

As support for the work on the model, the excavation plans were transferred to computer to facilitate analysis and visual imaging of the large quantity of data. This part of the work was carried out by naval architect Kenn Jensen (Jensen, 1999; Bischoff, Jensen, 2001).

The plan of the excavated nails and rivets, with all the associated information, was intended to form a basis for computer-generated drawings. Before this could be done, however, all the information had to be given in a format that could be used in a computer.

The excavation plan was positioned on a grid which functioned as a coordinate-system. The nails were measured and the coordinates entered into a data-base, together with information of the level (the z coordinate), the number of the nail, its dimensions and character, supplementary comments (wooden structure left in the rust around the nail, the orientation of the nail, etc.).

It was decided to use a data-base as the 'entry' into the computer, since the Ladby material consists of a large number of objects which mainly contain similar information. Among the objects entered it was then possible to search for specific information in a rapid and efficient way. This again gave a very good overview of the demanding material, and served the purpose of the database exactly.

All information from the database was transferred in table form to a standard spreadsheet. In that programme, a number of adjustments of data were made, for example correction for baseline and scale-adjustment. The nails and rivets were sorted according to their length and type. Finally the structured data were written out in a format that could be read by a drawing programme. With the database material as starting point, two different types of drawings were first produced: projection drawings and sectional elevation drawings (Fig. 13.6).

A projection drawing is made by projecting a 3D structure down onto a 2D plan. Projection drawings were made in the three main planes (elevation, waterline, and sectional elevation). On each of these three drawings, the nails and rivets were divided into size and type. This division was carried out both with signatures and using different layers in the drawing programme. For all the nails and rivets, the number was also given together with the special signature.

This three-dimensional nail-plan can be compared with a cloud of dots. It is of course not possible to make a section from such a picture. In order to make cross-sections, it was therefore necessary to cut some thin 'slices' out of the cloud of dots, and to project these on the YZ plane. These projections can, with a relatively large degree of certainty, be considered as sections of the cloud of dots. These 'sections' play an important role in constantly controlling the reconstructed hull-form via the original form.

The process from note-books to drawings was built up in such a way that it was possible to update the drawings rapidly and easily. This means that when changes were made in the base-material, the drawings could easily be changed thereafter.

In the first part of the reconstruction process, the computer was primarily used to provide a better overview of the archaeological material; however in the later part of the process the computer played a more active role, functioning as a powerful supplement to the model and as a means of effective control of the process. This again made it possible to document the reconstruction process.

Shortly written the process was as follows:

1. The information was transferred from the database to the spread-sheet by a table.
2. The information was rewritten, using a standard tool for the standard spreadsheet.
3. Data was rewritten and transferred to the graphics program for further processing. This gave us the plan of the nails and rivets.

A wire-frame model was first built up in the computer programme called I-ship, developed at the Department of

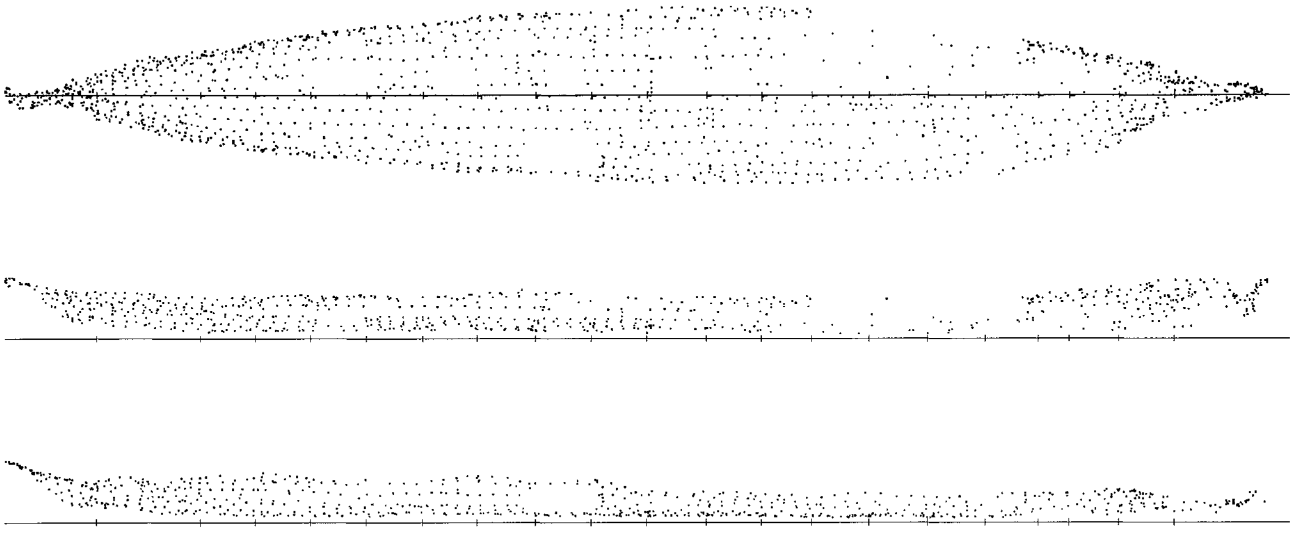

Fig. 13.6. The computer-generated plan of the nails and rivets in the Ladby mound, lying in the soil at the time they were found. The plan has been produced on the basis of measurements made during the excavation.

Naval Architecture and Offshore Engineering in Denmark. In principle, this was defined in the same way as the model-arrangement, using frame sections and nail-lines. The only difference was that the computer model also contained a contour line and some additional sections at bow and stern. Since the measurements were directly comparable between the model set-up and the computer model, all changes carried out to the model could be transferred to the computer model and vice versa, so that at any time the shape in the computer was the same as on the model. This made it possible to keep control of the reconstruction according to the original imprint as well as documenting the reconstruction process. The inter-action between the two models was fully exploited.

In the shape-identification process, the computer was a powerful supplement to the physical spline model. The advantage of the computer model was, in particular, the great precision with which the computer worked. This meant that even very small irregularities which could not immediately be seen on the model were visible on the computer. Another advantage of the computer model was the possibility of studying individual frame sections separately or together with a selected number of adjacent sections. The disadvantage in relation to the shape-identification process was the lack of clearness of the overall layout, which was one of the distinct advantages of the physical spline model. The ability of the computer to produce precise drawings quickly was used to give an even better image of the shape and for the final documentation of the reconstruction work.

During the whole reconstruction process it was necessary to be able to control the deviation between the model and Thorvildsen's sections, and between the model and the nail-plan 'sections'. The basis enabling this control to be carried out was produced by the computer. This was done by combining information from Thorvildsen's sections, frame-sections from the spline model and the sections from the three-dimensional nail and rivet plan, and creating a visual image of this on one drawing (Fig. 13.7).

The product of the computer model, the rivet lines-drawing, was printed out (Fig. 13.8), and the inner edges were estimated on its basis (Fig. 13.9). In order to use the material further, the inner edges were entered into NMF-ship, a computer programme developed by Kenn Jensen at the Centre of Maritime Archaeology in Denmark. This programme was made in order to be able to document and analyse ancient ship hulls. In this programme the inner edges are required to generate an outer hull for making hydrostatic measurements and an average hull for making fair water-lines. The outer hull and the average hull are generated on the basis of information given to the programme about the thickness of the planks and the breath of the overlap.

Internal structure and shipboard details.

After finishing the reconstruction of the hull shape, the complete structure of the ship still remained to be settled. The internal structure was thus based on all available material from the find itself as well as observations of other Viking Age finds, selected on the basis of similarities in date and type. The parallel finds chosen were *Oseberg* (*ca.*820), *Gokstad* (*ca.* 895), *Hedeby 1* (*ca.* 985), *Skuldelev 2* (1042–43), and *Skuldelev 5* (*ca.* 1040). These ship-finds are comparable in hull type and/or date and they served as very important elements in the reconstruction of the structure of the Ladby ship and its elaboration. The following details could be discovered in the original find itself:

1. By analysing the length of the rivets and the descriptions of the wooden structure remaining on the nails and rivets, the thickness of the planks as well as

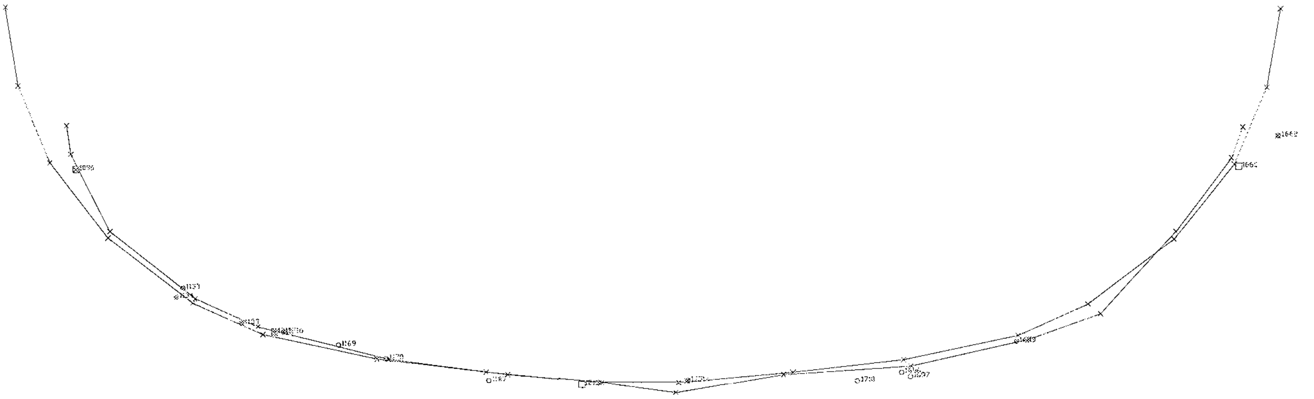

Fig 13.7. Cross sections from Thorvildsen, the nail and rivet plan and the cross sections of the reconstructed hull form were superimposed on top of each other, in order to document the reconstruction.

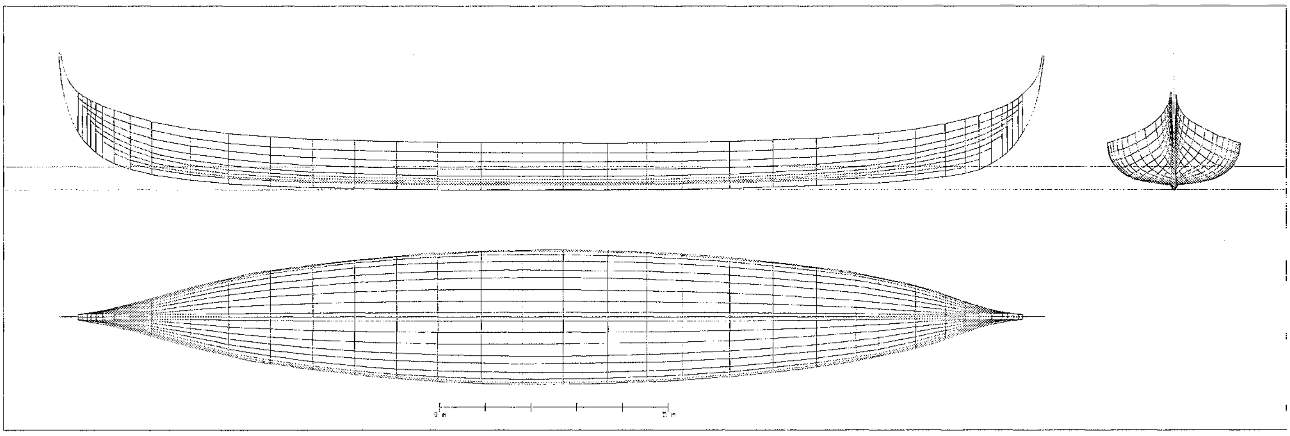

Fig. 13.8. The computer-generated rivet-lines drawing

the wood species could be extrapolated. The rivets belonging to the fourth strake were 9 cm long in the top of the strake, and 7 cm at the bottom. This shows that the ship had a meginhufr, a strong thick plank running the full length of the ship as a longitudinal re-enforcement. All other planks were *ca.* 2.5 cm thick in the middle, and 2 cm at the overlap. The analyses made of the wooden remains all revealed that they were of oak.

There was caulking material from sheep hair between the strakes and in the scarfs.

There were traces in the ground of plank mouldings: three embossed lines spaced unequally. This moulding might be similar to the mouldings on the Gokstad ship.

2. By searching for short rivets in the database (2.5–3 cm), examining the photographs of the imprint, and superimposing the lines drawing on the nail and rivet plan one were able to locate scarfs. They were not positioned exactly opposite each other, but staggered by about 40–50 cm from port to starboard and normally through scarfs of about 10 cm length.
3. The remains of the frames and the long nails that had fastened them to the third and the fourth strake, show a frame spacing of *ca.* 90 cm. By studying the photographs from the excavation, it was possible to measure the breath of the frames and to establish their approximate shape. They were about 7 cm broad over the keel and 9–10 cm at the second and third strake. These frames are the same dimension and shape as those of the *Skuldelev 2* and *5*.
4. In the excavation diaries there were descriptions of a solid piece of wood that seems to have been a stringer along the second plank from the top. This stringer is the key find in understanding the internal structure of the Ladby ship. This feature indicated that the Ladby ship had had an internal structure similar to that of *Hedeby 1, Skuldelev 2* and *5*. These ships all had stringers as a part of their construction as well as two layers of crossbeams and knees. This is unlike *Gokstad* and *Oseberg* that do not have any stringers and only one layer of beams. The internal parts were therefore reconstructed on the basis of *Hedeby 1* and *Skuldelev 2* and *5* (Fig. 13.10).

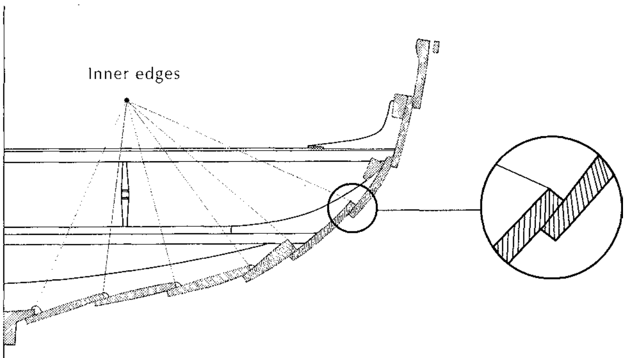

Fig. 13.9. Definition of the inner edge of the strakes and the location of the rivets used in the various lines drawings.

5. Seven big iron rings for the shrouds were found during the excavation lying along the sheer strake and indicating the position of the mast. No remains of the keelson were found.
6. In both ends of the ship, iron remains from some sort of ornament were found. Ten iron spirals situated in the prow might have been part of a decoration representing the curls on the neck of a dragon head. It was tempting to reconstruct the dragon head using that on a mould for an ornament found at the Viking Age market place of Birka in Sweden (Fig. 13.11).

In the stern, fragments of an oblong band of iron and nine to ten iron triangles in the shape of spearheads were found. These most likely symbolised spikes on the dragons tail.

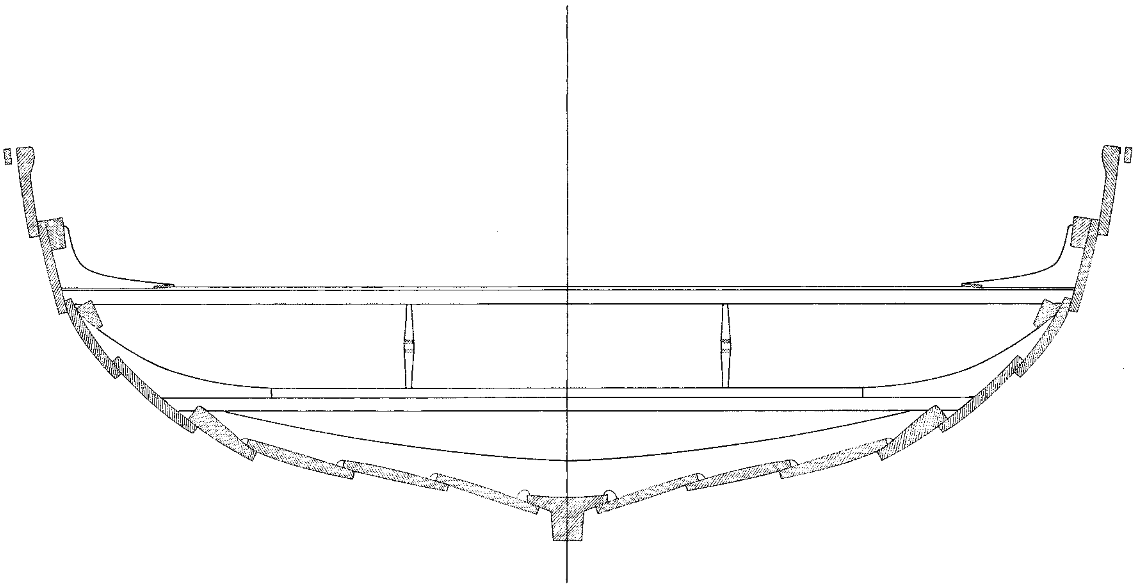

Fig. 13.10. Cross section of the Ladby ship with the internal timbers drawn in.

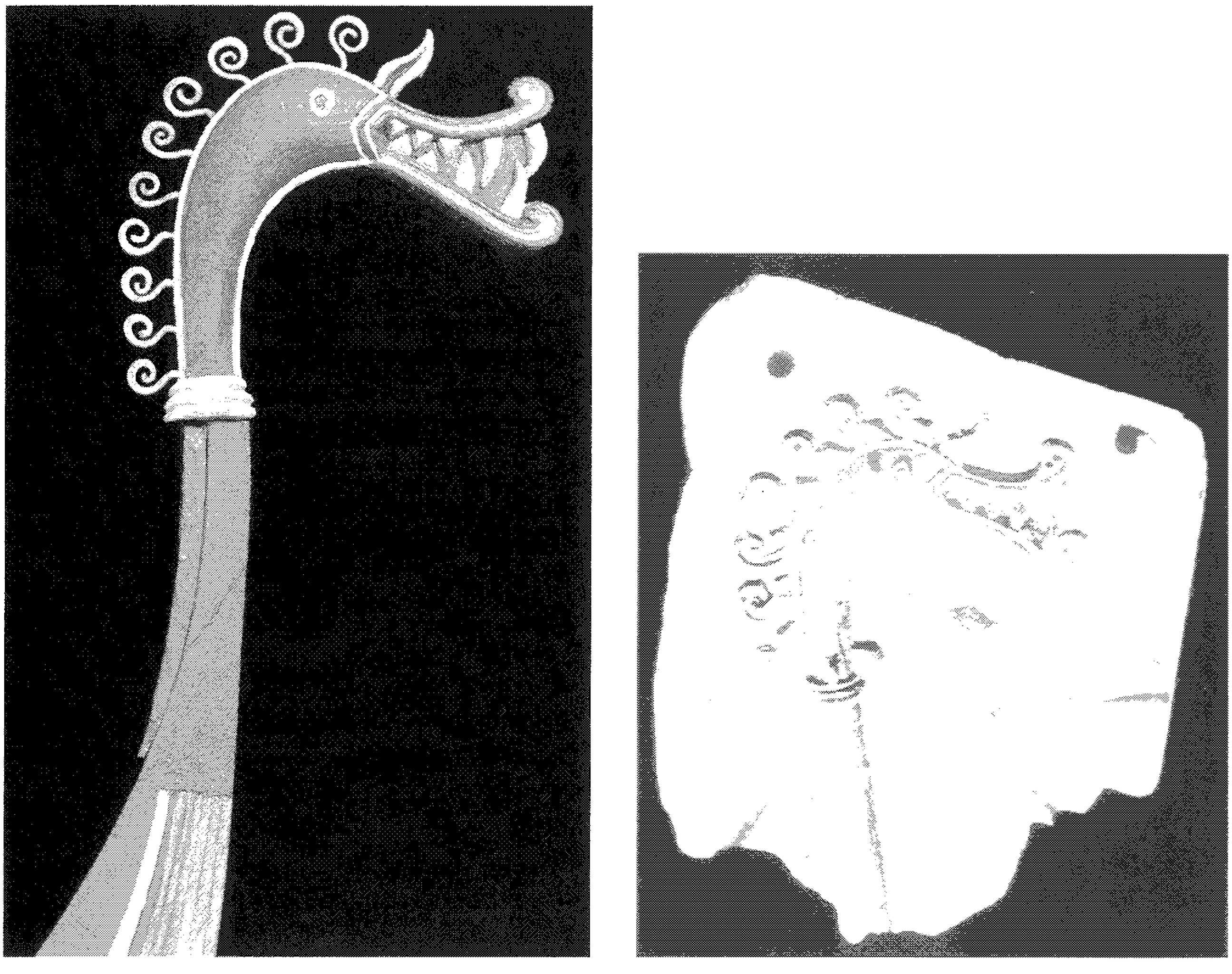

Fig. 13.11. Photograph of the decoration of the dragon head reconstructed on the background of a small mould for an ornament found in Birka in Sweden (photo: W. Karrasch (reconstruction), Statens Historiska Museum (original mould)).

7. Traces of paint, mostly blue and yellow, were found in several places in the ship imprint. On the outside of the ship, directly on the clay, traces of yellow paint were found. In several places inside the ship, blue, yellow and red paint was found. However most of the colours were blue and yellow. Some of the colours might have been used on the grave chamber that was build around the dead, but this was not possible to tell from the excavation diaries.

It was not possible on the basis of these fragments to determine exactly how the ship had been painted, but by referring to the Bayeaux tapestry, other iconographic material and written sources it was possible to form an idea of what it may have looked like before it was buried.

A wooden model was build in the scale of 1:10 (Fig. 13.12). The building of such a model serves two purposes. First, it creates in detail a useful and solid basis for the possible later construction of a 1:1 replica, and secondly the model is a way of visually communicating information in a museum. The model can be seen as an open history book where answers can be found by looking and perhaps wondering about some of the many details.

Analysis of the paint from other Viking Age finds shows that it was based on linseed oil (Krog, in press). The yellow colour was usually auric pigment, but could also be ochre. The blue colour, which was very costly in the Viking Age, was most frequently Egyptian blue (made from copper) or ultra marine (*lapis lazuli*). The model was therefore painted with ochre and ultra marine pigments in linseed oil.

The sail on the model is dyed with vegetable-extracts in colours that were used in the Viking Age. The sail was made of a densely-woven fine cotton, which is meant to imitate wool, the most likely material of the original sail. The sail was coloured with blue and yellow vegetable-dye also used during the Viking Age. In most cases, the yellow pigments in archaeological finds of textiles from Denmark and Norway have not been identified (Walton, 1988), but it has been possible to determine that in textile finds from Sweden the yellow colour was derived from the weld plant (*Reseda luteola*). Weld is one of the oldest known pigments in Europe and has been used since Roman iron age. Weld is a biennial plant which still grows in Denmark. It makes a very durable and bright yellow colour and is the only yellow plant with these qualities. Analysis of the blue colour shows that it contained the pigment indigotin. In the Viking Age Scandinavia indigotin was extracted from the woad plant (*Isatis tinctoria*), which was already being imported into Scandinavia in the Roman Iron Age (Hald, 1980). Indigotin is also found in the sub-tropical plant indigo (*Indigofera tinctoria*), but indigo was not imported into Europe until the 17th century. Both colours are very concentrated and resistant to light.

The decoration of the ship, with the dragon head and tail, and the strong colours on the hull and sail, are important elements in describing the contemporary appearance of the ship, and in creating as accurate a picture as possible of the Viking Age colours. Impressive it was and impressive it must be!

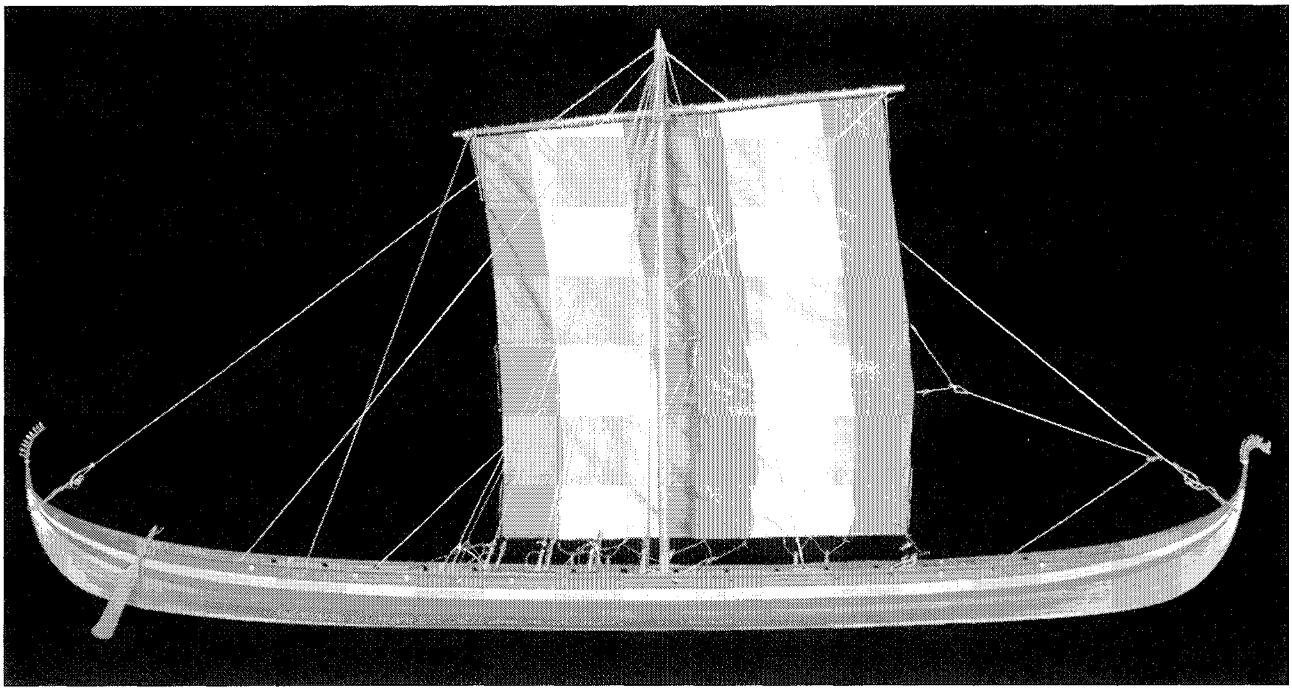

Fig 13.12. A wooden 1:10 model of the Ladby ship as it may have appeared in the 10th century, built by the author.

Conclusions

The present reconstruction has to be reckoned as the most realistic proposal for what the Ladby ship looked like. An exact replica is something we will never achieve, since there are so many questions and unknown variables. But now a reconstruction is made in which all the available information has been taken into account: characteristic of nails and rivets, and the remains of the wooden-structure around them, the remnants of wood and the shape of the impression in the soil etc. These variables, in conjunction with information of other ship gives a good idea of what the original ship might have looked like.

The model is on display at the Ladby Ship Museum, Kerteminde, Denmark, where it provides a dynamic illustration of what the grave ship of Ladby looked like 1000 years ago.

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14. Progress in the Study of Ancient Shipsheds: a Review[1]

David Blackman

The Size of Dockyards in the Classical and Hellenistic Period: Historical Sources and Archaeological Evidence

1. At one end of the scale one has the really large dockyards with over 200 shipsheds: Piraeus, Carthage and Syracuse.

Piraeus (Fig. 14.1). After the Persian wars the Athenians built shipsheds for their new fleet; they were destroyed by the Spartans after 404, and rebuilt in the 4th century in larger numbers. The naval records inscribed on stone give a total of 372 shipsheds in the later 4th century; they occupied the entire shoreline of Zea (196) and Munychia (82) and the south end of the main harbour, Kantharos (94). The main archaeological evidence was provided by a rescue excavation of 1885 on the north-east side of Zea harbour (Dragatses, Dörpfeld, 1885; Blackman, 1968). So much has depended on the measurements provided by these excavations, that it is good that they are being thoroughly checked by a Danish student, Bjoern Loven. Meanwhile excavations have been carried out on a group of 3–4 shipsheds on the west side of Munychia, but so far little information has been made public. If it is true, as press reports say, that the clear widths were 5.20 m, then we shall have some new calculations to do! For the moment we have to base our conclusions on the 1885 excavations

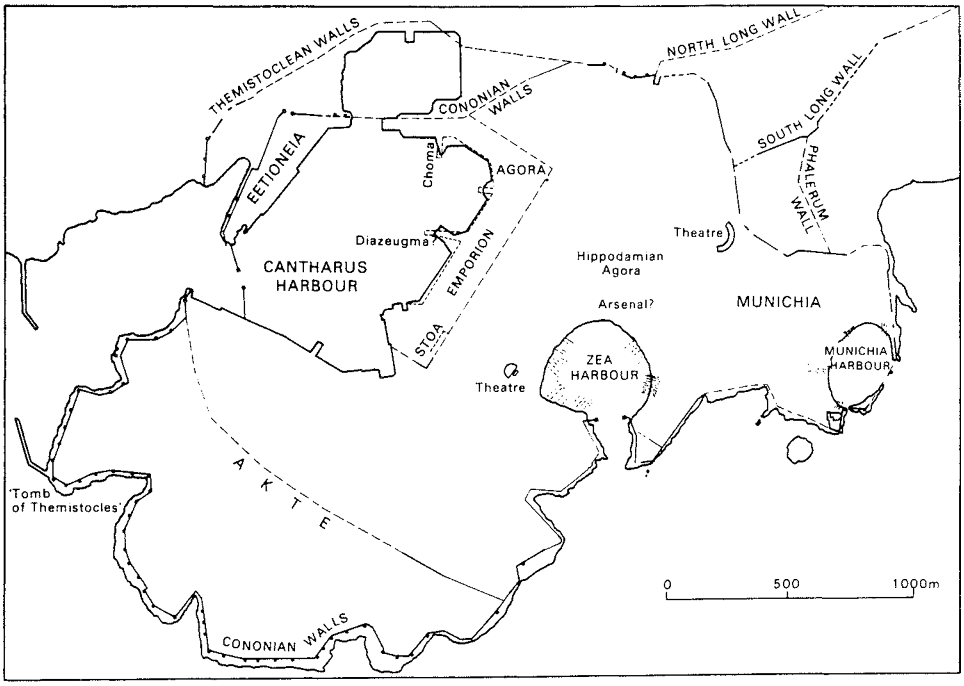
THEMISTOCLEAN WALLS
CONONIAN WALLS
NORTH LONG WALL
SOUTH LONG WALL
PHALERUM WALL
EETIONEIA
Choma
AGORA?
Diazeugma?
EMPORION
STOA
CANTHARUS HARBOUR
Theatre
Hippodamian Agora
Arsenal?
MUNICHIA
ZEA HARBOUR
Theatre
MUNICHIA HARBOUR
A K T E
'Tomb of Themistocles'
CONONIAN WALLS
0
500
1000m

Fig. 14.1. The harbours of Piraeus (after Blackman, 1982: 189, Fig. 3)

(also hoping that excavation will become possible at the south-west corner of Munychia, where a large site remains free of heavy overbuilding).

In the published Zea shipsheds, the clear widths between the columns were just under 6 m; this has been assumed to define the maximum beam of the ancient trireme (and was the point of reference in the construction of the *Olympias*).

It has normally been accepted (including by me) that the standard trireme shipshed would also have housed the new warship types which were developed in the 4th century: *tetreres* ("quadrireme") and *penteres* ("quinquereme"). But this is less than certain. Therefore further study in Piraeus and elsewhere is important, and publication of work already done.

If a number of the shipsheds in Zea and Munychia were well under 6 m in clear width, this would help to solve the problem of how the (known) numbers of shipsheds were squeezed into the (known) length of shoreline. Some scholars have suggested that perhaps some shipsheds were long enough to house two ships; I am hesitant to accept this, and would rather wait for more evidence to be made available. What *is* clear is that most other remains of shipsheds have clear widths not far from 6 m, and these must have been usable by "threes", "fours" and "fives".[2]

At *Carthage* a similar question has confronted the excavators: how to accommodate the (known) 220 shipsheds on the (known) shoreline of the Ilot de l'Amirauté and the outer edge of the Circular Harbour. Here the shipsheds excavated were mostly 5.9 m wide and a few were wider. Again we have the impression of complete use of the military harbour shoreline to accommodate a fleet at the height of its power. H. Hurst, the excavator, is in fact forced to suggest that up to 50 shipsheds lay in the adjoining Rectangular Harbour, which was the Commercial Harbour (Blackman, 1990: 41; 1995a; Hurst, 1993; 1994).

Syracuse has until now been a complete mystery. As with Carthage, we know from ancient sources that it had an impressive group of shipsheds; that most of the 160 built by Dionysios I at the end of the 5th century took two ships; and that he restored the existing 150 shipsheds, for a fleet which he increased from 110 to over 310 ships (Diodorus, 14.42.5). Hitherto little concrete evidence has been found; but we hear of important recent discoveries on Ortygia during public works, and hope to learn more in the near future.[3]

The only oddity in this group of large dockyards would be Cyzicus, if Strabo (C575) is correct that it had over 200 shipsheds. There is no archaeological evidence to support such a large figure. Lehmann-Hartleben found the figure "riesengross", which I take to express surprise or even doubt (Lehmann-Hartleben, 1923: 101n.1).

2. We have no dockyards attested with a ship capacity between 200 and 100. There then seems to be a category of medium/large military harbours which cannot yet be fully defined: we need more evidence and more study of the evidence which we have. This is not a category which has received attention hitherto. I suggest a size range of 50–100 shipsheds.

A good example of this medium/large category is Rhodes, where what is now Mandraki was the ancient naval harbour (Fig. 14.2). Since it contained, at least in one corner, a separate section with narrower shipsheds, there was probably no problem in fitting in the number of shipsheds needed for the Rhodian fleet at its prime. The shoreline was about 600 m, and remains of shipsheds have been found at several points. But no ancient source gives us a figure for the number of shipsheds, nor for the size of the fleet. Various analyses, including mine, have reached different figures, but 100 ships seems a reasonable maximum; these would (just) fit in the shoreline available (Blackman, 1995a: 230–231; Blackman *et al.*, 1996).

After Rhodes I think of harbours like Thasos, Massalia, Samos, Chios and Corinth.

Thasos had an impressive military harbour and an important fleet (it contributed 30 ships to the allied fleet) until its defeat by Athens in 465–3. Some underwater remains have been interpreted by A. Simossi (1998), quoting French archaeologists and archaeological architects, as remains of curious triple shipsheds, 20 m wide and over 40 m long. Her theoretical reconstruction of the military harbour gives it a capacity of 48 ships maximum, but the corners look awkwardly tight, and the remains are not fully convincing.[4] However, Thasos must have had a fleet of about 50 ships in the 460s: it lost 33 ships and went on fighting.

Other naval powers in the Aegean had fleets, and no doubt dockyards, in the early 5th century, until their subjugation by Athens. Samos had famous shipsheds built by the tyrant Polycrates *ca.* 530 BC, the earliest in the Greek world which are attested by literary sources; but no remains have been found. Samos under Polycrates had 40 triremes and 100 penteconters (Herodotus, 3.39.3; 3.44.2).

For *Naxos* and *Mytilene* we have no literary or archaeological evidence. For *Chios* we have the evidence of Strabo (C645): it had a *naustathmos* for 80 ships. This is not quite the same thing as saying 80 shipsheds, but gives a useful indication of magnitude of the port of a naval power not suppressed by Athens until it revolted in 357 BC. Strabo in the same section refers to launching triremes from the *neoria*, and Aeneas Tacticus (11.3) refers to the *neoria*.

In the western Greek world *Massalia* stands supreme. The discovery of Hellenistic and earlier shipsheds at this Greek colony was reported in 1993, and two rescue excavations have been carried out along the west side of the Vieux Port before construction of underground car parks. Running across the entire width of the first site (Place Jules Verne) were remains of 3rd–2nd century BC shipsheds, with timber slipways: either cross beams (*traverses*) set in the beach or mobile timber rollers with rope slings around pairs of pegs at either side (Fig. 14.3). The timbers showed marks of usage: the fixed timbers

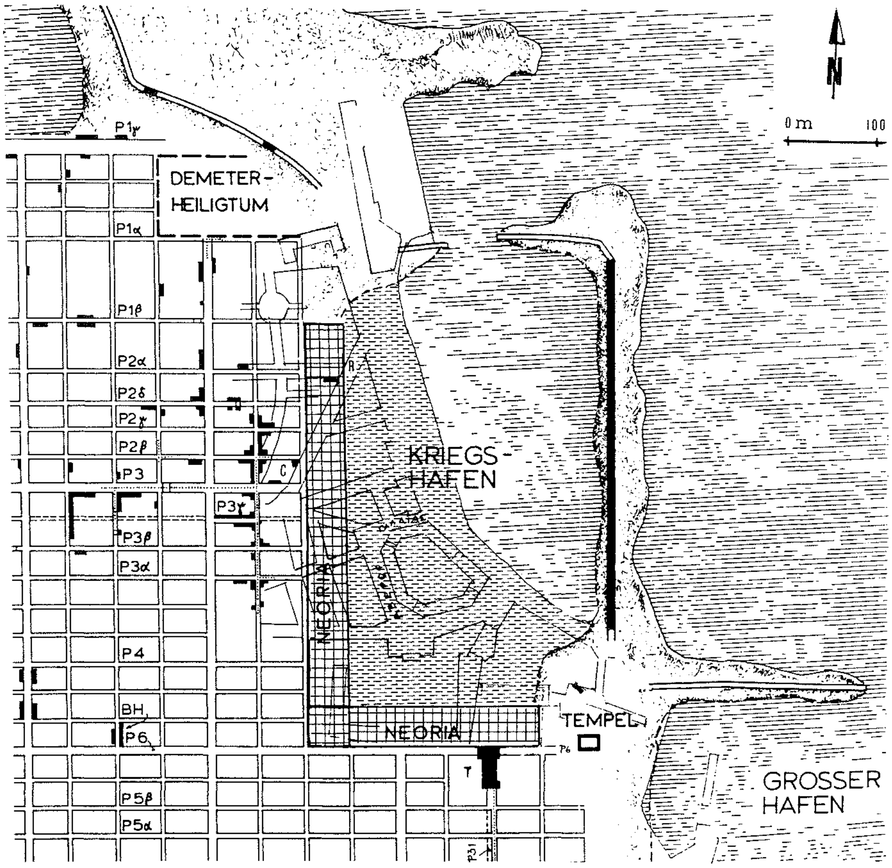

Fig. 14.2. Rhodes: the ancient naval harbour, now Mandraki (after Blackman et al.*, 1996: 374, Fig. 1)*

bore traces of ships' keels and the rollers bore traces of ropes (Hesnard, 1995; Hesnard *et al.*, 1999: 37–38, 156; Hermany *et al.*, 1999: 26–27). The second site (Villeneuve-Bargemon), being further inland, revealed also the upper (inland) part of at least three slipways with similar cross beams and rollers; here the side walls were preserved, of stone, which at the lower end were continued by massive vertical timbers (probably more practical at the shore line). The walls were over 40 m long and 5.50–6 m apart (Hesnard, 1998: 81–82; Hesnard *et al.*, 1999: 38–39, 156; Hermany *et al.*, 1999: 127–128).

As for the size of the dockyard, the excavator estimates that there was room for over 60 shipsheds (with a maximum of 70) (A. Hesnard, pers. comm.).[5]

Corinth, the major naval power on the Spartan side in the Peloponnesian War, able to send a fleet of 90 ships overseas at the start of the war, had shipsheds at Lechaion (attested in the literary sources) and must have had also at Kenchreai; Sparta too, at its out-port, Gytheion. But we know nothing of them archaeologically.

Kerkyra had a total fleet of 120 triremes in 433 (Thucydides); some traces of shipsheds have been found (Kanta-Kitsou, 2001), and it is hoped to re-study a site excavated in the early 1970s on the southeast side of the north harbour, close to the Agora; there are also recent reports of discoveries on the east side of this harbour. The size of the dockyard is not yet clear, but it was clearly in the medium/large range. Kerkyra had one of the major fleets of the Greek world in the 5th century.

3. The third category I have defined as medium/small (10 to 50).

Early in the Peloponnesian War (late 429 BC) the Peloponnesians planned a surprise attack on Piraeus from *Megara* (Thucydides, 2.93.2), though there was an Athenian look-out station with 3 ships (which were caught by surprise and seized) on Cape Boudoron opposite. They were able to launch 40 ships – which turned out to be in pretty poor condition (not having been launched for a long time), so the attack was called off. Clearly Megarian naval power was by then a thing of the past (they had contributed only 12 ships to the Peloponnesian fleet for the attack on Kerkyra in 433), but their ships were still "in dock". One dockyard of this medium/small category is known only from Strabo (C309): the dockyard of *Pantikapaion* (Kertch) in the Crimea held 30 ships. This important Greek colony on the straits of Kertch leading to the sea of Azov (lake Maiotis), was founded in the 7th century and became the capital of the Bosporan kingdom in the 5th–4th century; it would have needed a relatively

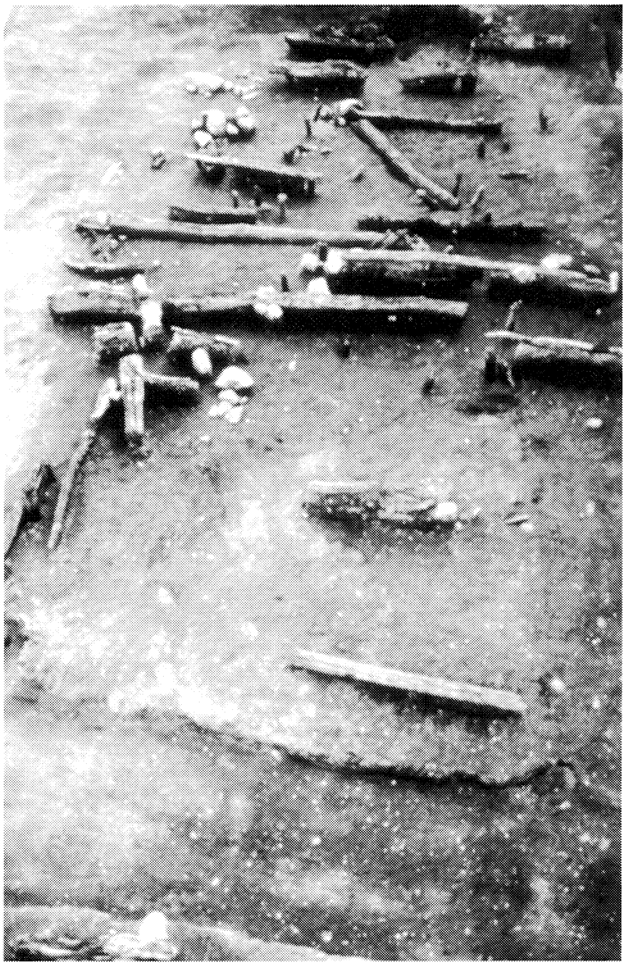

Fig. 14.3. Massalia: timber rollers in the Hellenistic shipsheds (courtesy: A. Hesnard)

significant navy, to protect its important maritime commercial interests.

Probably also falling into this medium/small category would be *Aegina*, where a group of six shipsheds were identified by Paul Knoblauch (1972). They fall into the standard trireme category (clear width just over 5.75 m), but they have not been further investigated. There may originally have been many more; possibly this was a medium/large dockyard until 457 BC.

Another military harbour still to be studied is the west harbour of Cnidus in southwest Asia Minor, which Strabo (C656) described as a closable trireme harbour, and a *naustathmos* for 20 ships.

At nearby Kos only a small part of the dockyard has been found, with two well-preserved shipsheds with slots along the side walls for timber *traverses*, not yet fully published owing to the sadly premature death of Haris Kantzia (Kantzia, 1987; Blackman, 1995a: 232; Lianos, 1999). The original size of the dockyard is not clear.

At Apollonia, the port of Cyrene in North Africa, N. C. Flemming found a set of 10 rock-cut slips, with a clear width of 6 m. But there may have been more: Flemming saw a number of other possible traces (Blackman, 1968: 183–184; 1972: 103–109, and map fig. 14).

Important remains have been found in the port of *Kition* in Cyprus, in a small basin approached from the sea by a canal. It seems to have been lined with shipsheds; the early excavations have been published (Yon *et al.*, 1996; Callot, 1997); but there has been further work.[6]

A building *ca.* 37 m long housed at least 6 slipways, which went through 3 phases in the late 5th and 4th century. The remains of the side and back walls, of stone and mud brick, are preserved to considerable height. There is evidence for the roofing and possibly for hauling, to which I shall return. The excavators explain the raising of the slipway ramps as due to a silting up of the port. They think the basin was less than 40 m wide.[7] I do not know how many more shipsheds have been found, but clearly not more than 20 in all.

I am eager to learn about Avner Raban's new finds at Caesarea; and about the finds of Annette Schreur in Lebanon.

4. Any definition of a "small" dockyard is essentially arbitrary, but I have assumed that it can be applied where we can say that it definitely had a single-figure number of slipways; many of the sites already described have less than 10 preserved, but may well have had many more originally.

Here we can with some certainty put the dockyard of *Oiniadai* in West Greece: a rock-cut chamber containing 6 shipsheds of the 3rd century or earlier, with clear width just over 6 m and rather steep gradient. These were partly excavated by the American School early in the 20th century (Sears, 1904), and the work was completed in the mid 1990s by Dr. L. Kolonas. This does seem to be the complete dockyard, of a city of modest importance. In the early 4th century, at least, it was used as a naval base by the Athenians (Xen, *Hell.* 4.6.14).

At *Naxos* in Sicily (the first Greek colony in Sicily, founded in 734 BC) I have been able to identify remains of 3 slipways first revealed in 1982, while the director of excavations, D.ssa Lentini, is now working on the topography of the surrounding area, where knowledge of ancient remains derives entirely from rescue excavations in the face of urban and tourist development. It now appears that the shipsheds lie just within the archaic/classical city wall, with perhaps room for at most 2/3 more to the north, inside the wall; to the south the ground rises quickly to what may have been the agora (Fig. 14.4). We are dealing therefore with a maximum size of 5/6 shipsheds, and maybe only 3 (Blackman, in press a; in press b; in press c).

Another small dockyard is that at *Rethymnon*, with two pairs of rock-cut slipways, and no signs of any further remains (Flemming, Pirazzoli, 1981: 68–69).

5. The strangest group in my view is that of single shipsheds within a city site and port area; a single slipway (or two)

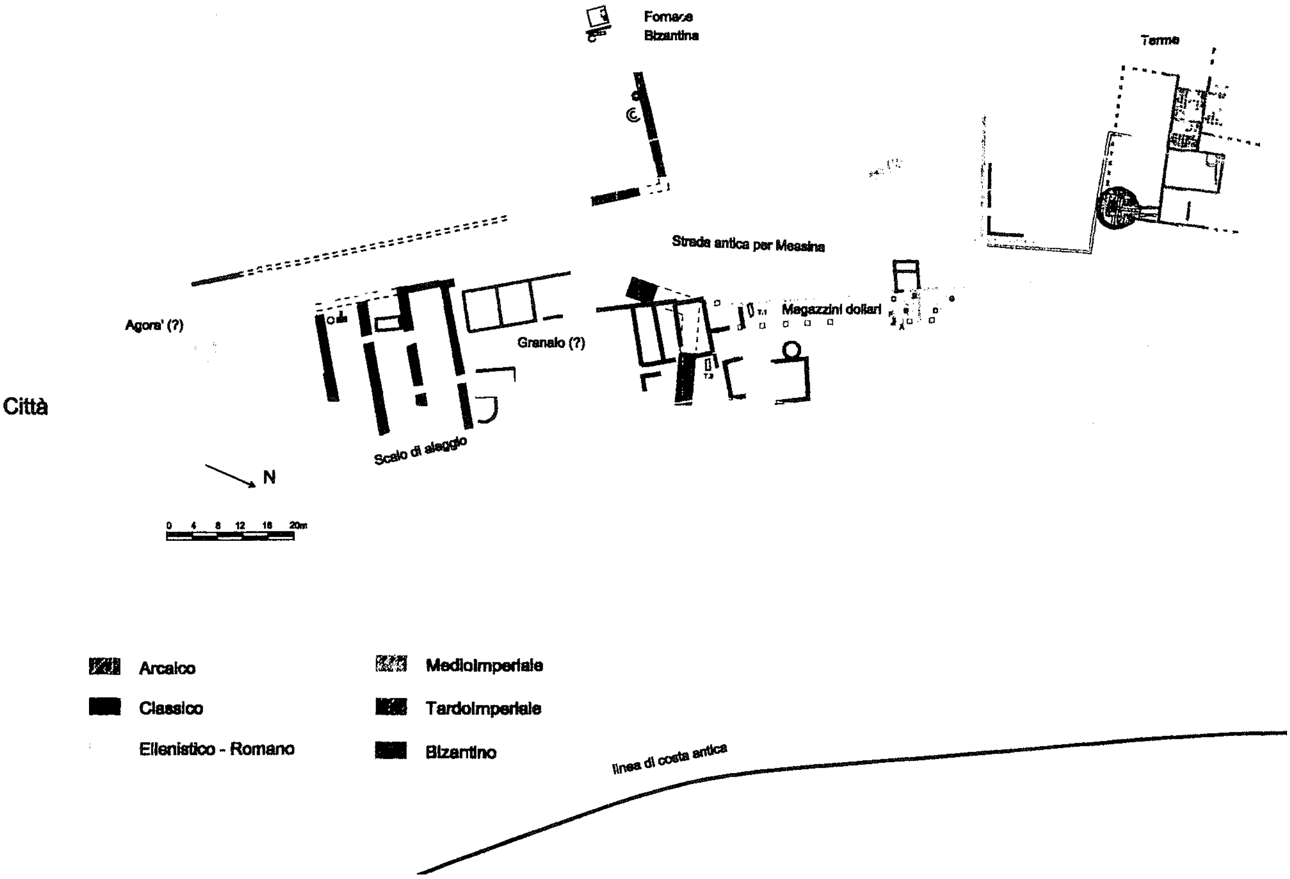

Fig. 14.4. Sicilian Naxos: plan of the north part of the city (courtesy: M.C. Lentini)

detached from a city site can of course be explained as constructed at look-out points or staging posts. At *Matala* only one rock cut slipway has been found (Blackman, 1973); and so far only one at *Abdera*, and very early – 6th/5th century (Samiou, 1999; but there may have been more). Can one imagine a city with *one* warship?

At *Antikythera* a single rock-cut slipway has been found not far from the ancient port (Flemming, Pirazzoli, 1981: 73); I have not seen it. A little farther away from modern Siteia is the single rock-cut slipway at Trypeti, but the ancient port city (in fact an out-port of inland Praisos) may as well have been near Trypeti, where there are Hellenistic remains, as under the modern town.

When the shipsheds are well away from a port one must look for another explanation. This is clear at *Sounion* (2 slips) where Thucydides also provides us with a historical context: 413/12, after the Spartan occupation of Dekeleia, which forced Athens to defend its seaward approaches.

There is also the context of "overseas naval stations" of an imperial power, such as Athens had at Oeniadai at least in the early 4th century and on *Atalante* Island on the coast of Locris, with 2 *neoria*. One of the ships was damaged by a tidal wave in the earthquake of 426 BC: this is known from literary sources (Thucydides, 3.89.3; Strabo, 1.3.20), but the exact site is not yet located, though we have looked; the station at Boudoron had 3 ships. There is also the possibility of a naval station providing defence in depth through an early warning system for a major maritime power, which is my suggested explanation (at least in part) for the 21 slipways on the island of Alimnia off the west coast of Rhodes (Blackman, 1996; 1999; Blackman, Simosi, in press).

I believe that this is the first time, at least since Lehmann-Hartleben, that an attempt has been made to answer the question about dockyard size and maritime importance. My answer may be unsatisfactory, but this reflects the state of the evidence; as the amount of evidence grows, it is important to ask such historical questions.[8]

Technical questions

In a review of the state of our knowledge of ancient shipsheds, written in 1993 (Blackman, 1995a: 232), I listed a number of questions to which we did not have a full answer; on three of these we can report progress:

1) where were warships built and repaired (or merchant ships for that matter)?
2) how were the shipsheds roofed?
3) how were ships hauled?

1) Shipbuilding yards

These do seem to have been separate installations from the shipsheds in antiquity; only minor repairs could have been carried out in the narrow confines of the shipshed, though on some there is slight evidence for something like the pits of a modern garage: at least one ramp (13) on the island at Carthage seems to have been designed to allow easier access to the ship's hull (Blackman, 1995: 73; Baika, in press); some strange features noted by Flemming at Apollonia could also be explained in this way (Flemming, 1972: 108–109; Blackman, 1990: 46–47); and I may be starting to find something similar at Naxos (see below), with puzzling longitudinal rock cuttings on a slip.

For specific shipbuilding facilities the evidence was until recently very slim (Blackman, 1982: 207; 1990: 45–47). A pair of slips at the 5th century BC city of Thurii in Southern Italy have a grid of slots for a timber grid or "cradle" to support a ship in the centre of a cobbled ramp with a shallow gradient (1 in 20) and plenty of clear working space. I have agreed with the excavator's suggestion that this was an installation for shipbuilding or ship repair (Zancani Montuoro, 1972/73; Blackman, 1977).

At Carthage Hurst has argued that the timber remains underlying the stone shipsheds of the final period (destroyed by the Romans in 146 BC) relate to shipbuilding activities: he found lines of timber post-holes and narrow trenches which he (with many years of rescue excavation experience in Britain) said were similar in appearance to prehistoric and early medieval post-built structures in Northern Europe. He argued that these could well be upright timber staves or stocks which shipbuilders use to support hulls under construction or repair. There were many such post-hole lines in sequence, indicating that each had been used for only a short time. In support of his interpretation he notes that evidence for metal-smelting was found in the associated debris. This interpretation falls short of proof, and one notes that it involves assuming that the military harbour must have lain elsewhere until the very last period of the city's independence (the first half of the 2nd century BC), which seems to me difficult.[9]

Now, however, we have clear and undoubted evidence of distinct shipbuilding facilities from *Marseille*: timber constructions on the beach with large pieces of timber, notably frames, being prepared for use (and abandoned on the beach) (Fig. 14.5), soaking pits, and evidence associated with shipbuilding: tools, wood shavings, ropes and templates (Hesnard, 1995; 1998:80; Hesnard *et al.*, 1999: 34–37; Hermany *et al.*, 1999: 78–79). The site dates from the 5th century BC.

How much the Marseille excavations are adding to our knowledge!

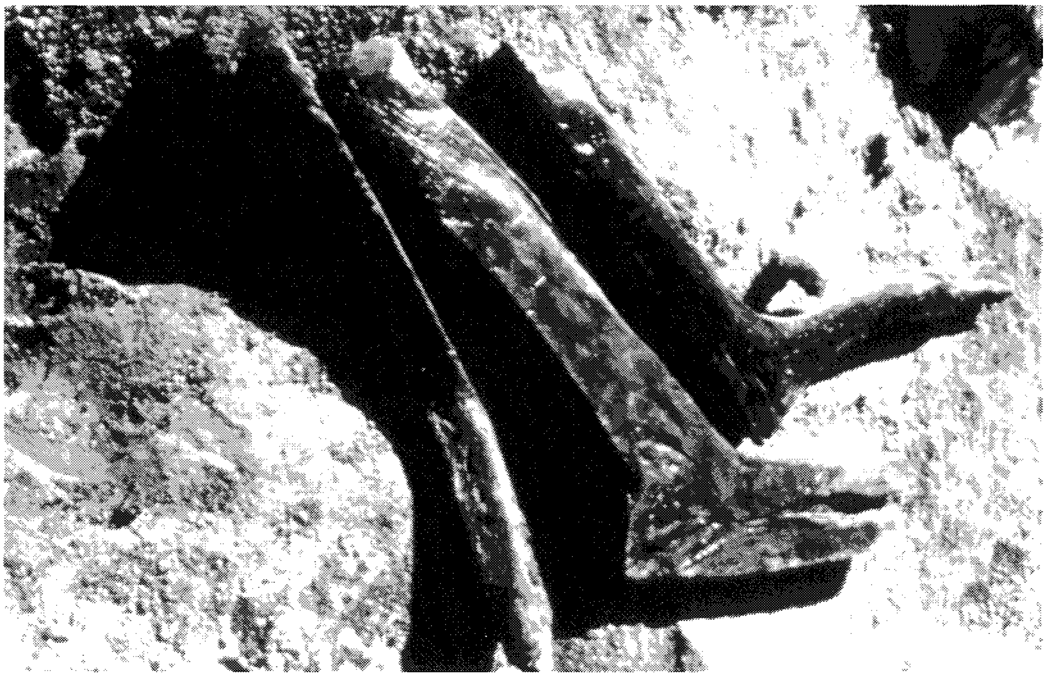

Fig. 14.5. Massalia: remains of 5th century BC shipbuilding activity (courtesy: A. Hesnard)

2) THE ROOFING OF SHIPSHEDS

For most of the last century it was assumed that the reconstruction proposed by Dörpfeld for the Piraeus shipsheds excavated in 1885 (Dragatses, Dörpfeld, 1885) was correct for that site, and it was fairly universally applied elsewhere. The roofing of the Sounion shipsheds, with two descending horizontal stretches, was regarded as a local exception for roofing a rock-cut chamber with a very steep gradient (Kenny, 1947).

A debate is currently under way, and the results have not yet been published. R. A. Tomlinson, an expert on the roofing of Classical buildings of a more respectable kind (e.g. the Propylaea of the Athenian acropolis), had discussed with me his doubts about the Dörpfeld reconstruction, and I have encouraged him to put them in writing. He accepts that there was at Piraeus a gable roof covering each pair, whereas elsewhere slips may have been roofed singly, or in groups with a flat roof. What he contests is the sloping ridge beam, which he feels would create major stresses at the foot of the structure.

On the other hand, J. Coates does not see this as a major engineering problem, and argues that the archaeological evidence mostly points to a gradually descending roof.

This is a debate in progress. It seems to me that at a number of sites, for example Oiniadai and Rhodes (Sears, 1904; Blackman *et al.*, 1996: Fig. 14.6), there is no doubt that the column bases (and therefore presumably the tops of the columns) descend gradually so that one can continue to accept the Dörpfeld solution; but we are now accumulating examples of shipsheds where the side walls form a series of descending horizontal stretches which indicate a roof formed of a series of descending horizontal stretches.

This has been clearly demonstrated by the French team at Kition, and their reconstruction looks plausible (Fig. 14.7).[10] The side wall at Marseille looks similar (Hesnard, 1998: 81–82; Hesnard *et al.*, 1999:38) and may indicate a similar superstructure. I now think that we have a similar situation at Naxos where I assume that the roof may have followed the side walls in a series of horizontal steps (Fig. 14.8). No traces of columns have been found, but they may have been removed for re-use (whether of stone or timber) when the city was destroyed in 403 BC; this may also explain the absence of roof-tiles from the 5th century BC level, but only a small area has so far been opened at that level.

In conclusion, I think that we must accept that both forms of roofing existed in classical antiquity.

3) HAULING GEAR

Finally, there is the question of hauling gear in shipsheds. It now seems generally accepted that on most slipways ships could not have been man-handled, and that a combination of hauling gear and greased timber groundways was needed.

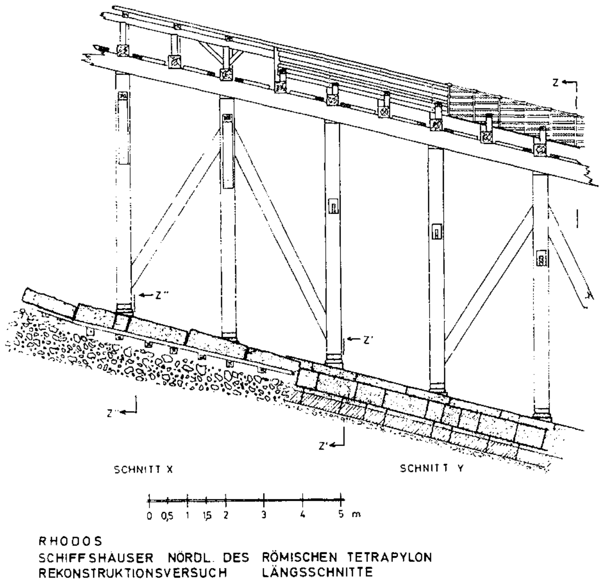
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Fig. 14.6. Rhodes: reconstructed longitudinal section of the shipsheds (after P. Knoblauch in Blackman et al., *1996: 399, Fig. 28)*

The evidence for use of timber on shipshed ramps is now considerable – as *traverses* or longitudinal runways or both – and I will not repeat the arguments I have used before (Blackman, 1990; 1995). The evidence for hauling gear remains slim, but it is starting to appear. At Kition the back wall of the shipsheds seems to have had fixtures for some horizontal arrangement at least for making fast the ships, and perhaps for hauling them.[11]

I may now be finding further evidence at *Naxos*. This site was excavated in the early 1980s and not fully understood; but its importance was realized and it was preserved from building development. Having suggested its identification, I was invited by M.C. Lentini to join her in re-studying the site and carrying out some further sondages.

So far we have investigated the two sides of one shipshed, at the level of side "doorways" which are a feature of this site (like Kition). A heavy overlay of 5th century AD house and street remains renders work difficult until a more extensive excavation can be financed.

On the north side the sloping bedrock was found with late 5th century BC pottery in the lowest levels above it and in pits in the rock, indicating construction not long before the city's final destruction in 403 BC. On the south side (much more disturbed by later levels) we have strange longitudinal trenches in the bedrock, not paralleled on the north side. Only one has so far been cleared over a short stretch (the other was waterlogged by the rain of September 2000), so it is premature to attempt explanation.

As I mentioned before, they (or one?) might have something to do with inspection pits rather than runways

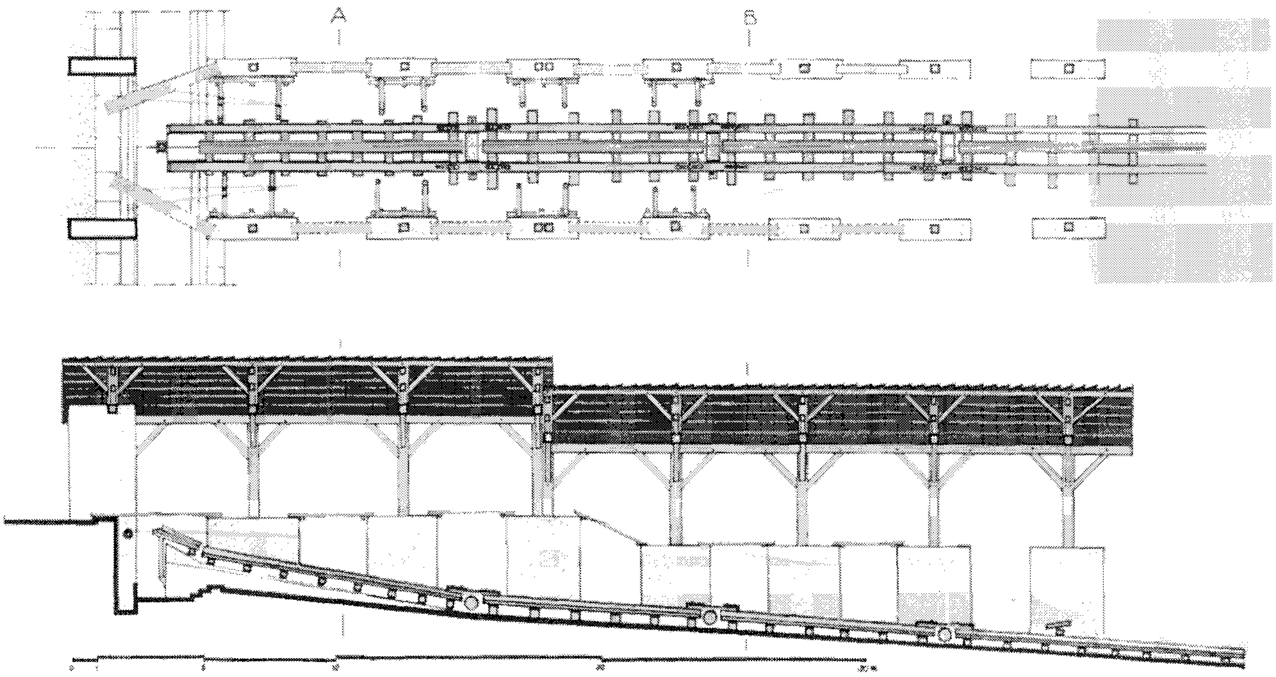

Fig. 14.7. Kition: plan and reconstructed longitudinal section of a shipshed (courtesy: M. Yon)

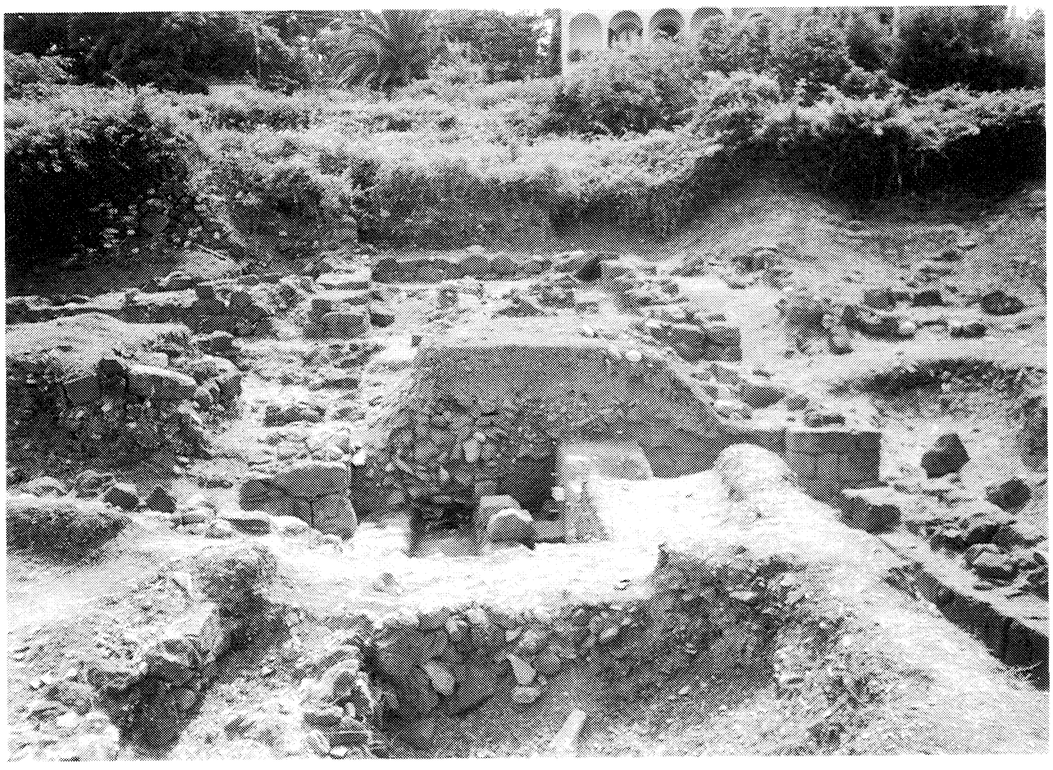

Fig. 14.8. Naxos: shipshed 1 from the east (seaward end) (photo: D.J. Blackman)

(which would be difficult to explain on only one side of the slip), but I cannot yet be sure that they have not been added later. They seem to cut through cross *traverses*.

Certainly belonging to the shipsheds are interesting "post-holes" in the doorways: one in the doorway in Wall 1, and now one on each side of the doorway in Wall 2.

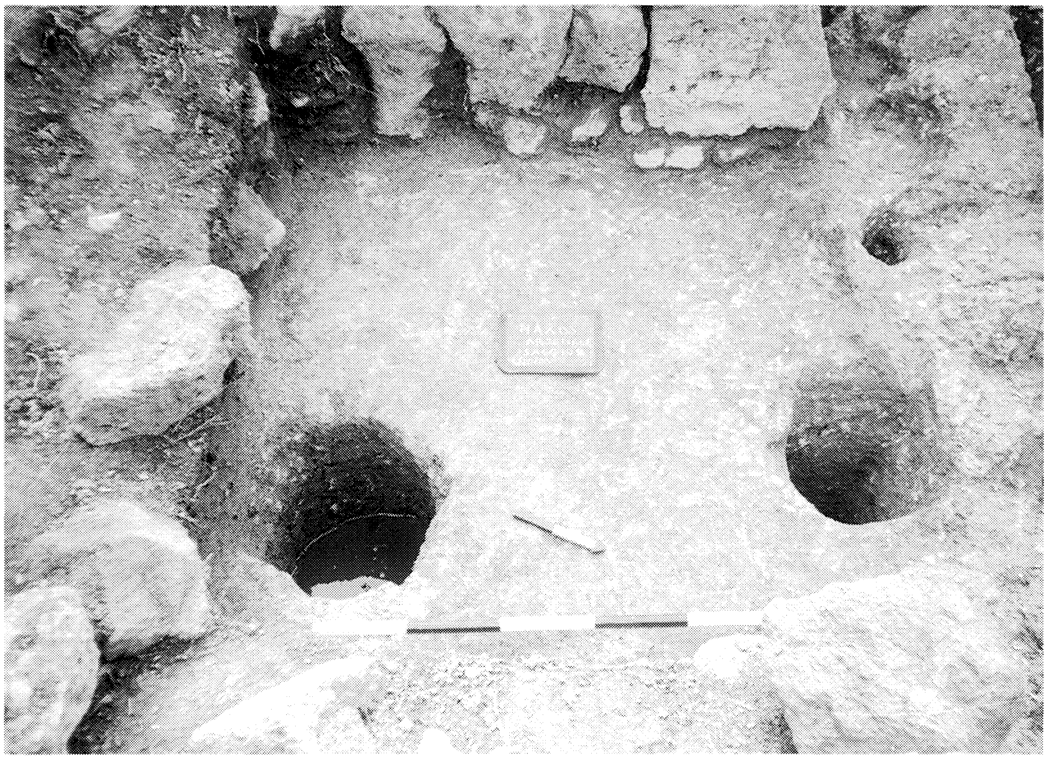

Fig. 14.9. Naxos: post-holes in doorway in wall 2, looking west (photo: D.J. Blackman)

The one on the north side of Wall 2 was accompanied by further cuttings in the rock which will require further investigation, along with the traces of settings for *traverses* (this excavation was carried out under wet conditions at the beginning of October 2000). The post-hole was clearly cut to hold the foot of a trimmed and roughly squared timber (Fig. 14.9; samples have been taken from this year's pits for wet sieving).

The post-holes clearly held vertical timbers, and project inside the line of the side walls of the shipsheds. I can so far offer two possible explanations:

(i) Either they supported tall timbers which acted as buffers to hold the ship steady during hauling, particularly at the moment of instability as the ship enters the water or leaves it and becomes or ceases to be buoyant. J. Coates discussed this problem in his paper for the 1999 Pylos Symposium, as earlier in 1993 (Coates, 1999; in press), and suggested that they relied on the roof supports to support the ship; I myself think they would have preferred free-standing timbers rather than endanger the roof (for the same reason I do not agree with Callot that ships were made fast to the roof supports).

(ii) An alternative idea would be that the post-holes contained the bases of winches for ship hauling. I wonder whether they are in the position one would expect. There may well have been more at the top of the slipways and we will have to examine that area and also the other side doorways. You can imagine my keenness to continue there and also to extend the small sondages we have started.

Notes

[1] I should like to dedicate this paper to John Morrison, who first inspired me with an interest in ancient ships and shipsheds and who saw the importance of the study of shipsheds.

[2] We have elsewhere (Blackman, 1995; 1995a; 1996) demonstrated that from the 3rd century BC at least a narrow category of shipshed can also be documented, with a clear width of just over 4 m, for the smaller warships which had been developed in that period, such as *hemioliae* and *triemioliae*. But this does not deal with the problem of the 5th–4th century.

[3] It is reported that during drain-laying, remains were found of about 20 parallel walls *ca.* 6 m apart. For earlier discussion see Lehmann-Hartleben, 1923: 106–107.

[4] My caution is shared by N. Lianos (1999: 263).

[5] It is sad that we did not have a presentation from Mme Hesnard at the Symposium.

[6] It is sad that Dr. Sourisseau was not present to report on the latest excavations.

[7] I should like to know how many more shipsheds could have lined its shore without making the ship operations totally impossible!

[8] Another question, that I cannot deal with here, is that of transfer of skills in shipshed/shipyard construction.

[9] Hurst (1977: 235) originally interpreted these structures as timber shipsheds, but rejected this view later (1979: 23; 1993).

I still incline to his original interpretation (1990: 41–42).

[10] This marks a change, correct in my view, from the earlier reconstruction proposed in Yon *et al.*, 1996: Fig. 3b; the earlier article had, however, suggested the way forward in emphasizing the difference between side walls and descending individual bases.

[In presenting my paper I showed a slide of Callot's reconstruction as published in *Res Maritimae* (1997: 77 fig. 6). Prof. Marguerite Yon has now sent me the latest reconstruction (Fig. 7), which will appear in Yon 2000, and in *BCH* 2000 'Chronique des fouilles 1999...Chypre'. She adds that it is now known from the 1999 excavations that there were 7 piers (not 6 as in *Res Maritimae*), corresponding to a length of *ca.* 40 m, as she has suggested from the start: we are indeed dealing with sheds for triremes of the same dimensions as those of the Greek type. I am grateful to Prof. Yon for providing me with the latest reconstruction and allowing me to publish it with this paper.]

[11] Compare Oiniadai: these sites are treated in more detail by Baika (in press). See also Blackman, 1990: 35–38.

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15. Ancient Slipways and Shipsheds on the Israeli Coast of the Mediterranean

Avner Raban

Though shipways, shipyards (Arsenals), dry docks and shipsheds are of prime necessity in any first scale harbour and were probably so at least since the Classical era, only a handful installations of these categories have been fully studied so far (see Blackman, 1968; 1982: 204–207). In the Levant, there are even lesser remains of such installations, in comparison with the rich maritime and naval history of that region. Except for the recently discovered artificially-built slipways, most probably as part of shipsheds for naval units, in a rather well dated stratigraphic context, at the *Bamboula* of Kition, in eastern Cyprus (Yon, 1995: 122–126), there is none of that type in the region. Some rock-cut devices, such as the emplacement for a winch, at the small Islet by the outer harbour of Sidon, in Lebanon, can hardly be dated more accurately than in a wishful thinking manner (see Frost, 1973: 83–84). Other rock-cut hollows and quarried platforms by the present water line might be established for one of the above mentioned functions, but might as well been just stone quarries, shipbuilding yards, or platforms for fishnets (see for example *Ezekiel,* 26.24, Old Testament). In that context it is interesting to present two cases of rather well-dated maritime installations from the Israeli coast of the Mediterranean. One is a shipyard from Tel Dor and the other is a shipyard from Caesarea (Fig. 15.1).

The Slipways at Dor

Tel Dor is a peninsular site about 30 km south of Haifa, which has been settled as a port city since early second millennium BC and remained functioning as such till the end of the Medieval era (Stern, 2000). Of the rich repertory of maritime installations that have been traced and studied along the waterline of that site (Raban, 1995), the one at the south side of the so-called "Love Bay" is presented hereby (Fig. 15.2).

The rock cut slipways at Dor seem to have been fully exposed to the scrutinized eyes of visitors and to the devastating erosion of the elements for generations. Yet

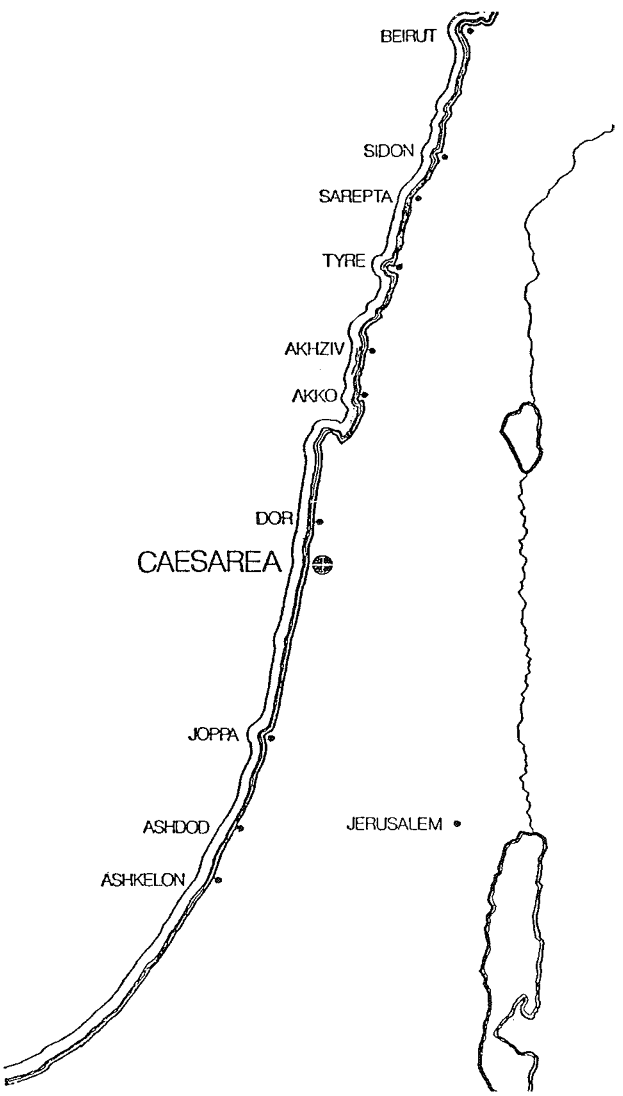


Fig. 15.1. General map of the Levantine coast and the sites mentioned in the paper (drawing: R.L. Vann).

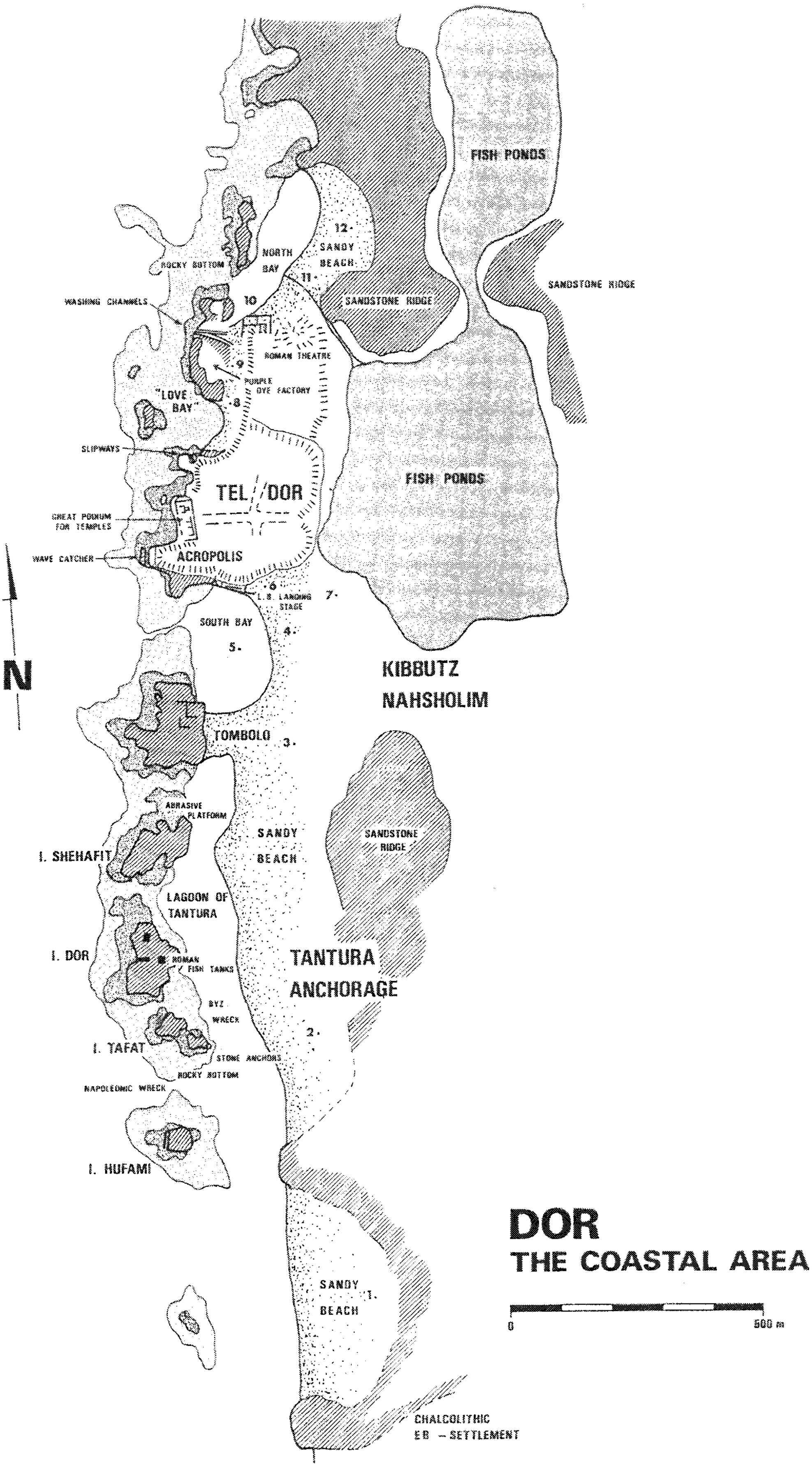

FISH PONDS
SANDSTONE RIDGE
12
SANDY BEACH
11
NORTH BAY
ROCKY BOTTOM
WASHING CHANNELS
10
SANDSTONE RIDGE
ROMAN THEATRE
9
PURPLE DYE FACTORY
"LOVE BAY"
8
SLIPWAYS
TEL DOR
FISH PONDS
GREAT PODIUM FOR TEMPLES
WAVE CATCHER
ACROPOLIS
6
L.B. LANDING STAGE
7
SOUTH BAY
4
5
N
KIBBUTZ NAHSHOLIM
TOMBOLO
3
ABRASIVE PLATFORM
I. SHEHAFIT
SANDY BEACH
SANDSTONE RIDGE
LAGOON OF TANTURA
I. DOR
ROMAN FISH TANKS
TANTURA ANCHORAGE
BYZ WRECK
2
I. TAFAT
STONE ANCHORS
ROCKY BOTTOM
NAPOLEONIC WRECK
I. HUFAMI
SANDY BEACH
1
CHALCOLITHIC EB – SETTLEMENT
DOR
THE COASTAL AREA
0
500 m

Fig. 15.2. Schematic map of Dor and the location of the slipways (drawing: A. Raban).

this unique installation was left unnoticed until recently (Fig. 15.3).

The slipways were quarried into the northern part of an up-tilted abrasive platform, which characterizes the segment of the coastal eolianite ridge the tell is based on. The platform at that point is presently about 3 m above the sea and rather eroded. Three hollows were cut there, sloping toward the sea, to the north, within the lee of "Love Bay". The uncut partition walls are presently worn away closer to the sea and the lower section of the sloping hollows is partly covered by more recent beachrock. So, only the southeastern part of the original complex has been amply preserved. The length of the rectangular hollows was originally almost 30 m and the width of each one, counting from east to west, is 3.8, 4.1 and 4.5 m (Fig. 15.4). The partition walls are 0.6–0.8 m high and 1.5 m wide. There are small round holes on top of them, at intervals of 1.8–2.4 m, that were probably made for insertion of wooden poles for a shade. The overall plan resembles the text of Vitruvius:

> The general rule for shipyards will be to build them facing the north. Southern exposures from their heat produce rot, the woodworm, shipworms and all sorts of other destructive creatures, and strengthen and keep them alive. And these buildings must by no means be constructed of wood, for fear of fire. As for their size, no definite limit need be set, but they must be built to suit the largest type of ship, so that if even larger ships are hauled up, they may find plenty of room there (V. 12.7).

Along the eastern side of the eastern hollow there is a 0.8 m wide bench, running along the upper 13 m of it. Three metres before its end there is a rock-cut staircase leading down to it from the nearby higher platform on the east. Farther to the north, along the eastern platform, at 16 m away from the back of the sloping hollow, there is a 2.4 x 4.1 m rock-cut basin, 2.7 m deep. Another two basins of a larger size were on the north west side of the complex, behind the western slipway, but it is presently too eroded to tell their exact original size and shape. These basins were probably for soaking ship logs in water, so it would be possible to bend them for the desired curvature without breakage. The back of the eastern slipway was found blocked by a cross wall, with some later ones on top, running eastward and creating a corner toward the north over the upper part of the slipway hollow, making it unusable for its original purpose. During the 1981 season, a confined excavation has been carried out in that area by Michal Artzy and a group of Danish students. These later walls were found to be in a context with a plaster floor on top of which some early Hellenistic sherds were found *in situ*.

Behind the cross wall, to the south, and aligned with the eastern slipway there is a 4×4 m room, partly cut in the rock and partly ashlar built.

It is possible that originally this space was used for a capstan or a similar pulling device, for carrying ship cradles up on the slope. Artzy's excavations over the eastern edge of the slipways have cleared a series of ashlar walls and several plaster floors, all dated to the Persian period. Yet, it is not clear in what way these structures

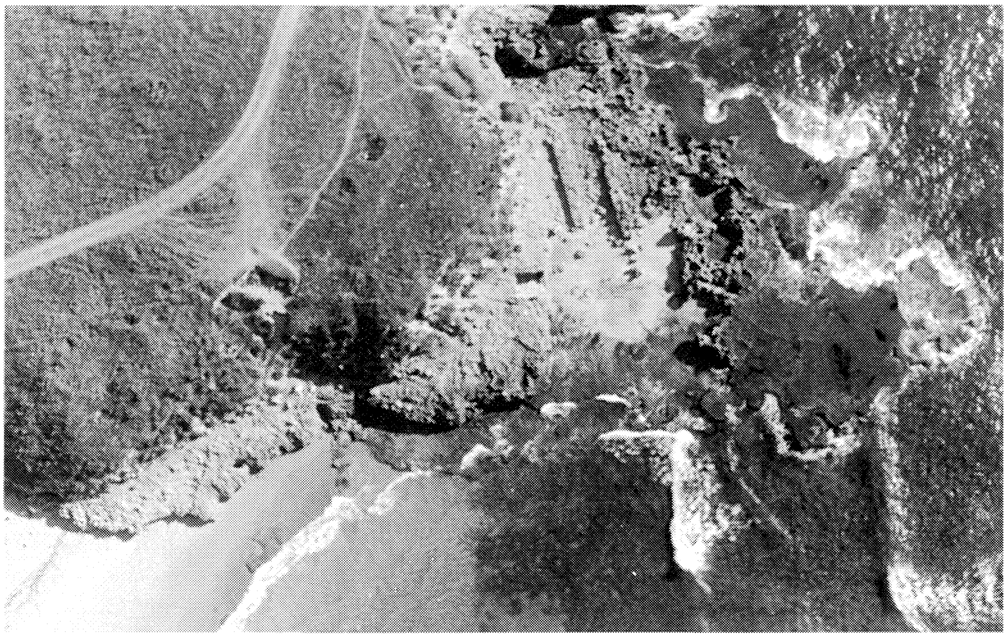


Fig. 15.3. Aerial photograph of "Love Bay" at Dor and the slipways. North at bottom (photo: A. Raban).

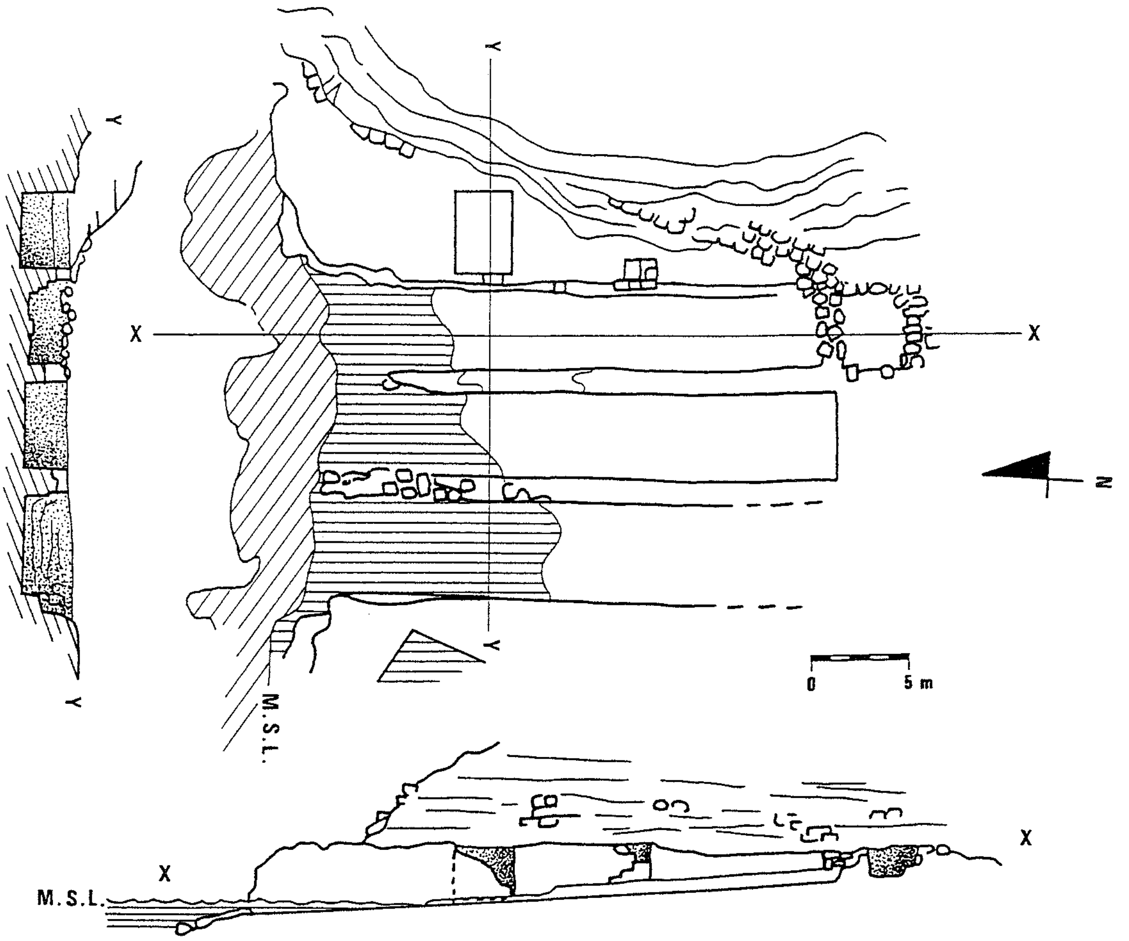


Fig. 15.4. Plan and sections of Dor slipways (drawing: A. Raban).

were related to the shipyard and whether they are of the same date. The only significant fact is that these walls are properly aligned with the rock-cut structure. So it is quite unlikely to presume that they predate it.

There are no good parallels to Dor's slipways in other sites from the Levantine coast. The known repertory of such installations comes from Greek settlements only. There are two major types of slipways:

1. Trireme shipsheds at strategic outposts, outside harbours and away from other portal installations. Such are the double slipways at Cape Sunion (Raban, 1981: 18, pl. I: 3). These are rather steep (15°), just over 21 m long and 5.5 m wide. There is a deep (1 m) and wide (2 m) channel in the spinal line of each one of the slipways at Sunion, probably for the heavy keel of a war craft. The size of these slipways does not fit a full-scale trireme. These were known to be almost 6m wide and up to 38 m long. So somewhat smaller patrol crafts might have been located there, guarding the entrance to the Saronic gulf (Blackman, 1982: 206).

   Somewhat larger slipway was found near Siteia in Crete. Also a rock-cut installation away from any known settlement. It is almost 30 m long and just over 5.5 m wide with a gradient of 16° (Davaras, 1967: 86–87). Both installations face north, as in Dor.
2. The major group of slipways is those known as shipsheds, or "neos oikoi" – the regular hangars for the Classical Greek triremes (Blackman, 1973a: 126–134). The largest known series of such shipsheds and the most famous is the 374 units along the shores of the twin military harbours of mid 4th century BC Piraeus. The larger naval base, the Zea, had 196 berths, some of which were excavated in 1885 (Shaw, 1972: 90–93), and the other one, the Munychia had 82. The rest occupied the south end of the main harbour, the commercial one, the Cantharus. The standard size of each berth was 37 × 6 m, with a gradient of 4.5° (the same as in Dor). There was no central slot for the keel, but rather a raised leveled rock-cut platform with lower recesses where the wooden poles for the gabled roof were placed. There are smaller groups of similar rock-cut shipsheds at Matala and Rhethymnon (three slipways) in Crete (Blackman, 1973b), and in Syracuse (not fully studied and presently covered by modern buildings).

Of a lesser resemblance to Dor's slipways are those found under the water at the presently submerged harbour of the Hellenistic city of Apollonia in Cyrenaica. Ten such slipways were found grouped together, facing south, toward the harbour basin, each one of somewhat different width and length (up to 40 m long and 6 m in width). Their average slope is just over 3° and most have a central keel slot (Flemming, 1972: 103–111).

Of the published data of this type of slipways, or shipsheds it is hard to build a typology with any sound datable, cultural or functional significance. Yet, there are enough comparative data and circumstantial documentation concerning ship sizes and length/breadth ratio for us to propose that the slipways of Dor were not mere shipsheds, but rather shipyards, where ship maintenance and replacement of rotten planking and frames took place. Considering that the maximum beam of treated vessels might have been somewhat behind the width of the hollows floor (due to the relatively low elevation of the sloping partition rock-cut walls, one can calculate that the eastern slipway could have accommodated a vessel up to 5 × 24 m, the central one 5.5 × 26 m, and the western one, being shorter, 6 × 20 m ships. This last ratio of marine vessel, of 1:4 is characteristic for a merchantman, while the other two could be used also as shipsheds for some type of an oared naval units (Blackman, 1968).

As for the suggested date for the slipways, though we have historic references for such installations in Egypt around 600 BC during the reign of Pharaoh Necho (Lloyd, 1975) and from the time of Polycrates, the tyrant of Samos (Herodotus, 3.45.4), a 5th century BC date seems to be more likely, considering the archaeological evidence for what might have been an Athenian presence at Dor, since that time (Stern, 1995: 272–275).

Potential "candidates" for shipsheds at Caesarea

Herod the Great initiate the construction of a large scale Royal harbour by 20 BC and add to it an adjacent city which "He dedicated to the province, the harbour (which he called Sebastos) to the men who sailed in these water, and the honor of the foundation to Caesar (Augustus, which may be translated in Greek to Sebastos): he consequently named it Caesarea" (Josephus, *Jewish War,* 1.414). Excavations are being carried at that site for over fifty years, on land and under the water. For detailed summation see for example Holum *et al.* (1988) and more updated at Raban and Holum (1996: XXVII–XLIV). Since 1992 the land excavations exceeded and were carried year round over a rather large area, along the coastline of the ancient site. Since 1997 the pace is slower and dictated again not by the demands of developing tourist resort, but rather by scientific scrutiny.

Learning much about the scope and technological sophistication of Sebastos (for short summary see Raban, 1998), one of the studied issues is the function this magnificent port had served to justify such "monster" as being more than "White elephant" or an expression of megalomania.

Within that context we are studying the notion that Herod the Great possessed a naval fleet, of which Caesarea or Sebastos was the proper base (Richardson, 1996: 178).

As we know, Herod issued, probably towards the end of his reign several types of coins with maritime motifs, including one with *aphlaston* and a small one, showing a warship (Meshorer, 1967: 129–132, no. 55). Herod has some navy of his own, probably a new one, built for him at the shipyards of Rhodes, of which he financed the renovations (*Jewish Antiquities*, 16:147). Josephus tells us also that Herod sailed out in order to assist his friend and patron Marcus Agrippa at his campaign in the Crimea during the summer of 14 BC (Jewish Antiquities, 16: 16–66). Though many scholars refer to this episode as if Herod came to the Black Sea with a fleet of warships (Schalit, 1962: 217; Richardson, 1996: 264), the actual text does not mention more than one ship. So one might not rely on it as a clear-cut proof for Herod's naval fleet.

If Herod did have a naval power and a fleet of warships, it is just possible that its base was at Sebastos. Yet, later on the only documented naval base of the Jewish country was at Yaffo (Joppa), with tradition and maybe even proper facilities, such as shipsheds *(nauskenea)* going back to the time of Simeon the Hashmonean, around 143 BC *(Macc.,* I, 13: 47–48, and see also Radan, 1988). Though the historical texts inform us about Sebastos as a port of departure and of disembarkation for various celebrities who would travel on specially dispatched warships (Ringel, 1988: 66), there are no indications that the Romans had kept there any naval units during the long-lasting campaign against the Jews (66–72 AD). That can be deduced from the fact that Vespasian had to send his garrisons by land only, when attacking the Jewish "Pirates" at Joppa (Jewish War, 3: 419–427), while a year earlier (66 AD) Cestius Gallus of Syria, did the same using his naval power, which was stationed at Seleucia (Gichon, 1981). A naval base demands facilities other than those provided by a regular commercial harbour. It usually would have its secluded basin, properly enclosed and furnished with docking stations, or shipsheds, in which the war galleys can be stored dry and well protected from the elements (see Blackman, 1982: 204–206 and bibliography). Were such facilities in Sebastos? Josephus does not mention them, or any military use of the harbour, which was to be used by "those who are sailing in these waters" (*Jewish War*, 1:414).

The archaeological data that has been extracted so far at Caesarea cannot contribute much for decisively answering the above-imposed question. Yet, at the waterfront of Herodian Caesarea and the lee part of Sebastos, there are three architectural complexes that might be considered relevant (Fig. 15.5):

1. The paved area at the NW corner of the Inner Basin (CCE area S and the adjunct area LL).

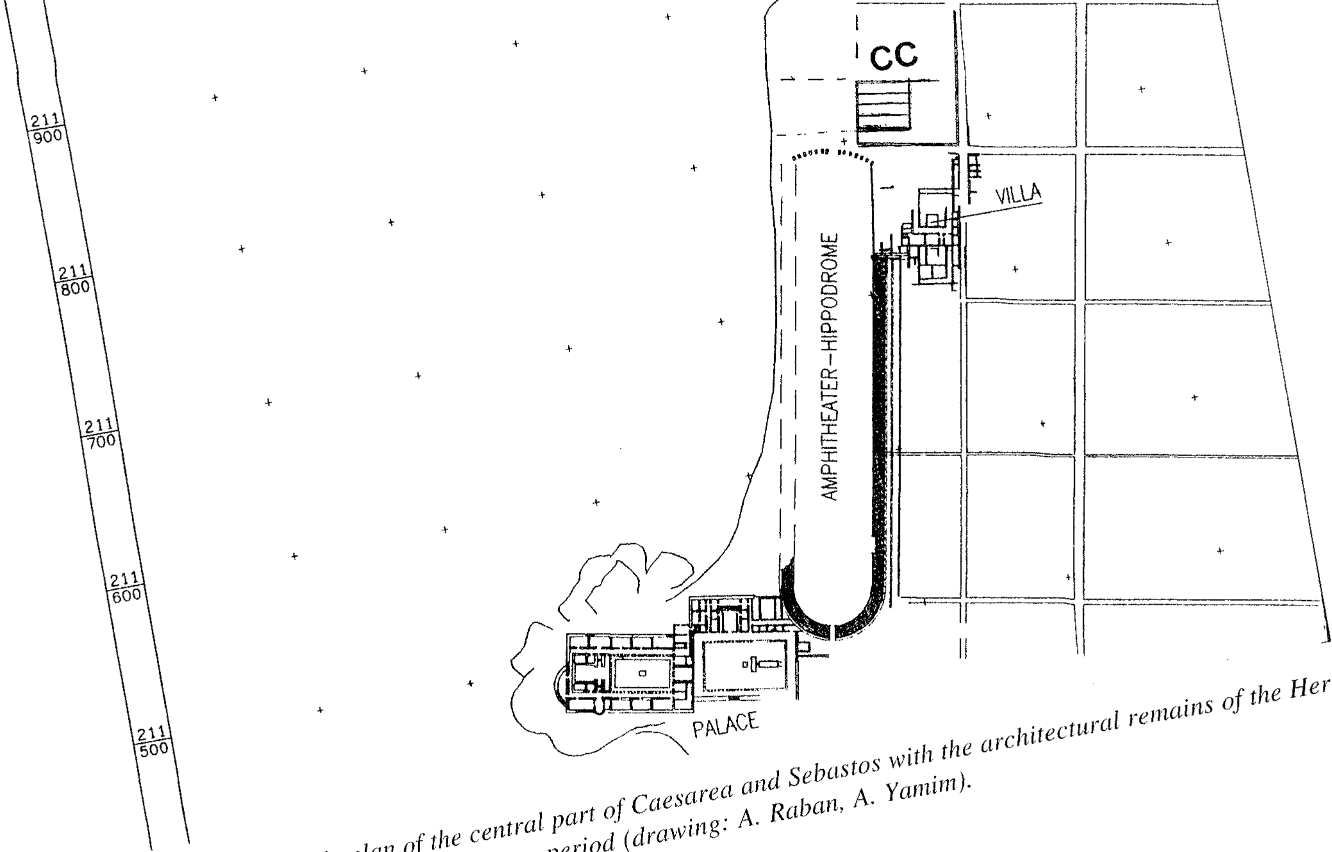
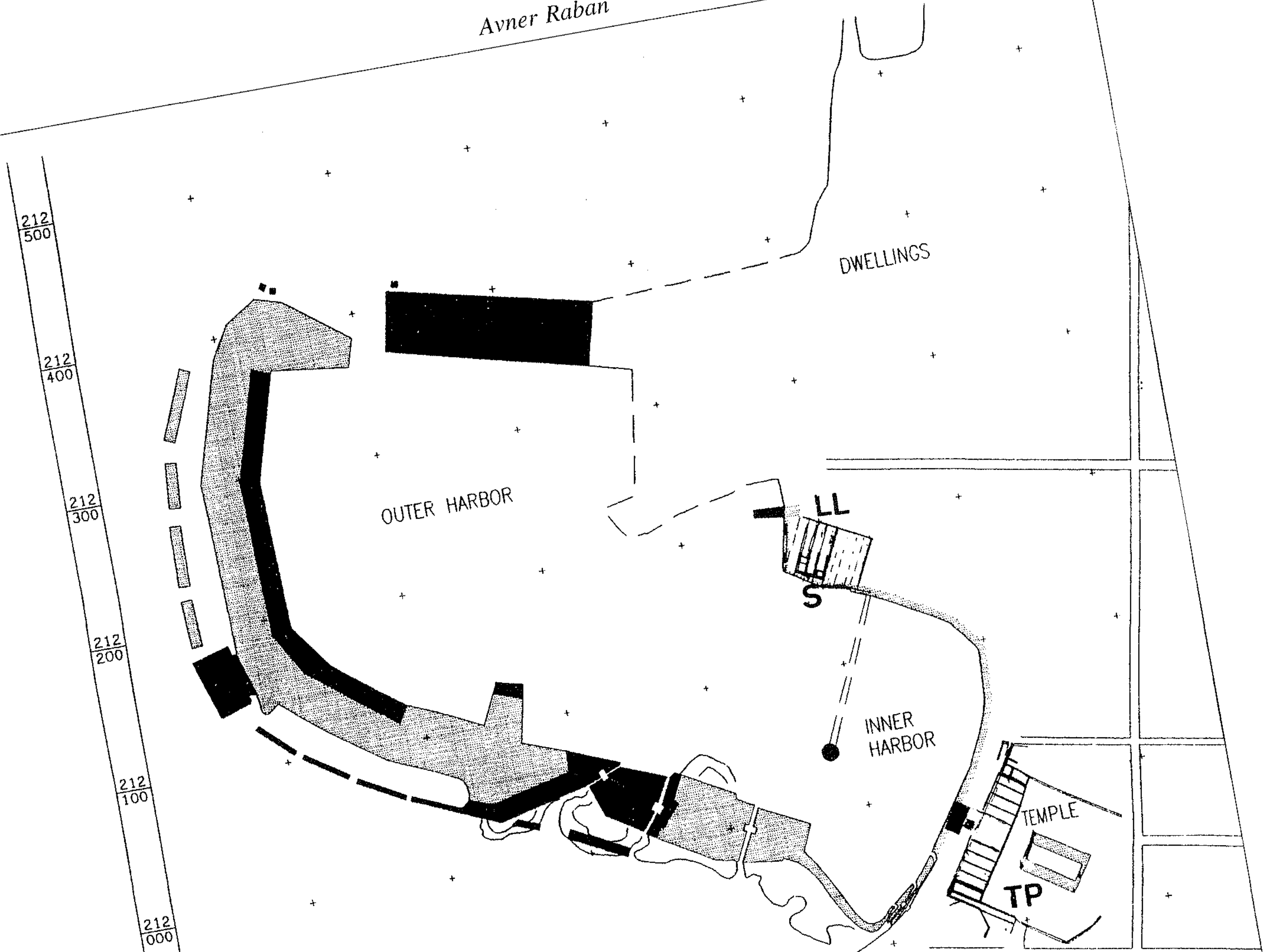

CC
VILLA
AMPHITHEATER–HIPPODROME
PALACE
211 900
211 800
211 700
211 600
211 500

Fig. 15.5. Schematic plan of the central part of Caesarea and Sebastos with the architectural remains of the Herodian period (drawing: A. Raban, A. Yamim).


212 500
212 400
212 300
212 200
212 100
212 000
DWELLINGS
OUTER HARBOR
LL
S
INNER HARBOR
TEMPLE
TP

2. The vaults at the western facade of the Temple Platform (Area I).
3. The vaults at the NW part of the South Bay (Area CV, and/or CC).

Area S (presently designated by CCE as the southern part of the Area LL) have been surveyed and partly excavated by the team of the Hebrew University during the mid 1970s (Levin, Netzer, 1986: 58–65) and by CAHEP, ten years after (Raban, 1989: 173–177). At that site the Hebrew University team has partly exposed what seems to have been a storage unit *(horreum)* of the Byzantine era. Recent CCE excavations have revealed two additional facts: a. The overall plan of a corridor flanked by two segmented series of storage chambers (Levine, Netzer, 1986, plan 3) is to be dated around 500 AD, and it is superimposed over earlier, probably Herodian, broader ashlar walls that would create three elongated, parallel confined spaces over 40 m long and just over 5 m wide, sloping gently towards the waterfront at their south end, facing the NE corner of Sebastos' intermediate basin (Fig. 15.6, and see Raban, 1989, figs. III, 164–169). Only the westernmost of the three have been exposed to the bedrock, with its closing wall at the south end wall, which

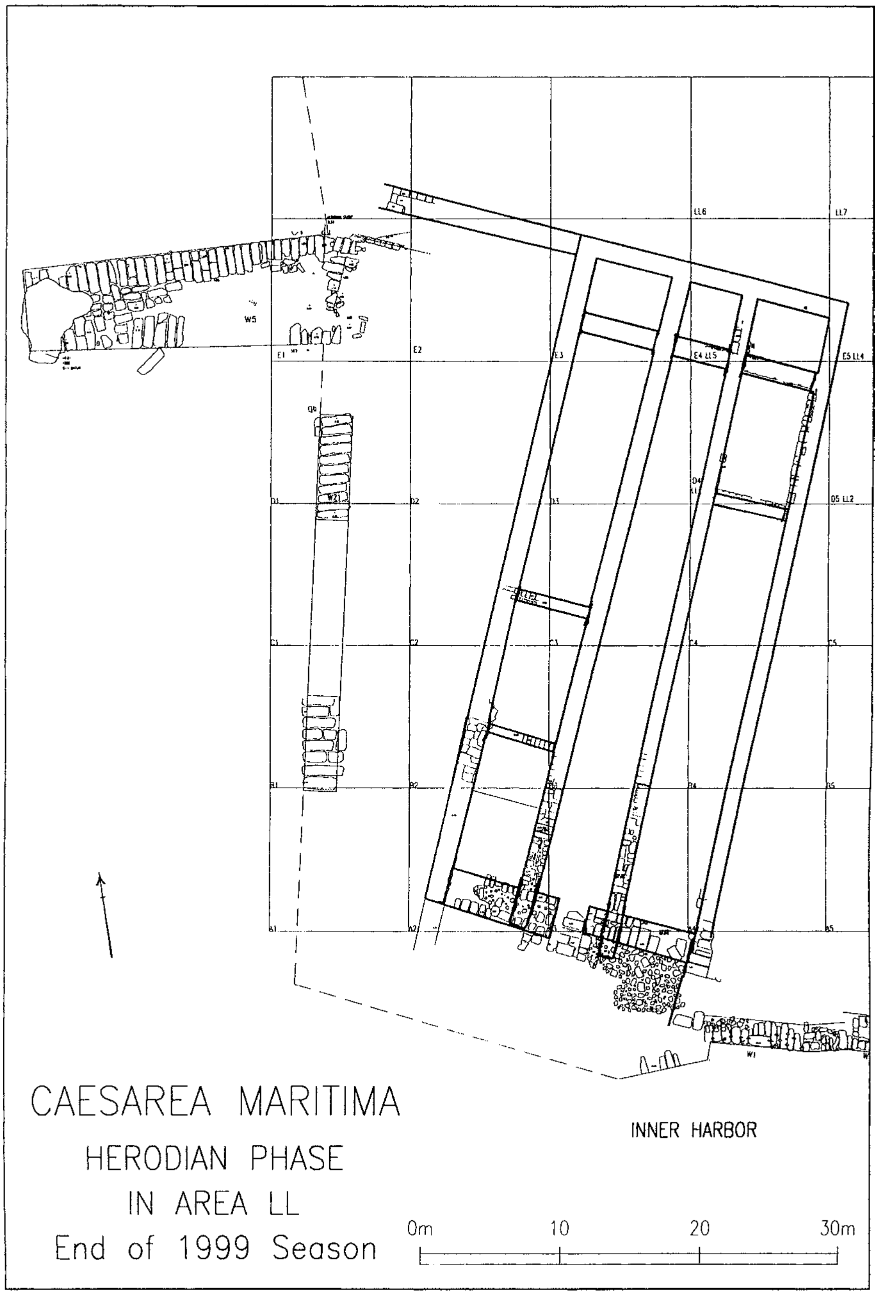


Fig. 15.6. The structures of the Herodian phase in area LL (drawing: A. Raban, A. Yamim).

seems to be a later addition, overlapping the ashlar headers platform (CAHEP's *Locus* 220), which might be of a pre-Herodian date. Yet this raised platform could serve nicely as the sliding device for the keels of stored naval units so typical for Greek, Hellenistic and Roman shipsheds, as was found at Zea of Piraeus (Casson, 1972, fig. 197) and in Oiniadai, Akranania (Fig. 15.7). Both shipsheds comprised a series of parallel spaces over 40 m long and 5 m wide that would accommodate triremes over 33 m long at their water line and 3.8 m broad (Coates, 1990: 115; Basch, 1995: 52–55). The southward sloping bedrock at the base of this pre-*horrea* complex had been quarried off as a sheer drop-off to the eastern side of its eastern confining wall (Levin, Netzer W.151 = CCE W.1171). This quarry defines a considerable hollow on its lee, an area of over 20 m on E–W axis and twice as much on a N–S direction, all the way to the harbour basin, to the south. No structures have been traced within that hollow of a date earlier than the 9th century AD (the Abbasid era). Either one of these two neighbouring areas, the *horrea* and the quarried hollow, might have been used once for shipsheds. But such assumption demands further excavations before it will be properly attested and accurately dated.

The vaults at the western facade of the Temple Platform has been partly exposed since the early 1960s (Raban, Stieglitz, 1988: 276; Raban, 1989: 138–142; Negev, 1993: 273; Patrich, 1996: 150–153; Porath, 1996: 107–109, 1998: 45–46). These published excavation reports are basically of a preliminary character and only CAHEP's includes plans, sections and pottery analyses (Raban, 1987; 1989, figs. III: 80–89; 1992: 13–16). The present issue concerns two groups of 4 vaulted chambers each, on both sides of the Herodian staircase that led from the water front of the Inner Basin to the Temple Platform (Fig. 15.8). These vaults are uniform in their dimensions, being 21 m long, just over 5 m wide and about 8 m high – from their original floor level to the inner apex of the vault. All eight vaults are facing the eastern quay of the inner harbour and though they have been designated as *horrea* it seems as if there was no closing wall along their western facades (Patrich, 1996: 153), but only a low retainer, built of marginally drafted ashlars to a height of over 2 m above the MSL (over one meter above the earliest floor, but almost at the level of the second one). He dates the vaults that have been studied by Porath to the 3rd century AD (Porath, 1998: 46), but it seems that there were earlier covered chambers at the area, either vaulted, or with a flat timber-based ceiling. The orientation and the open-front of these chambers might bear in mind shipsheds. But their length and absence of any central rampart or "keel slots" (see Blackman, 1982: 206) would make these chambers unsuitable for storage of triremes. Yet, it is possible to reconstruct a very tentative set of timber runners and cradling devices that would accommodate smaller galleys, such as two-level *pentakonters* (Coates, 1990). Such hypothetical reconstruction should consider timber infrastructure that

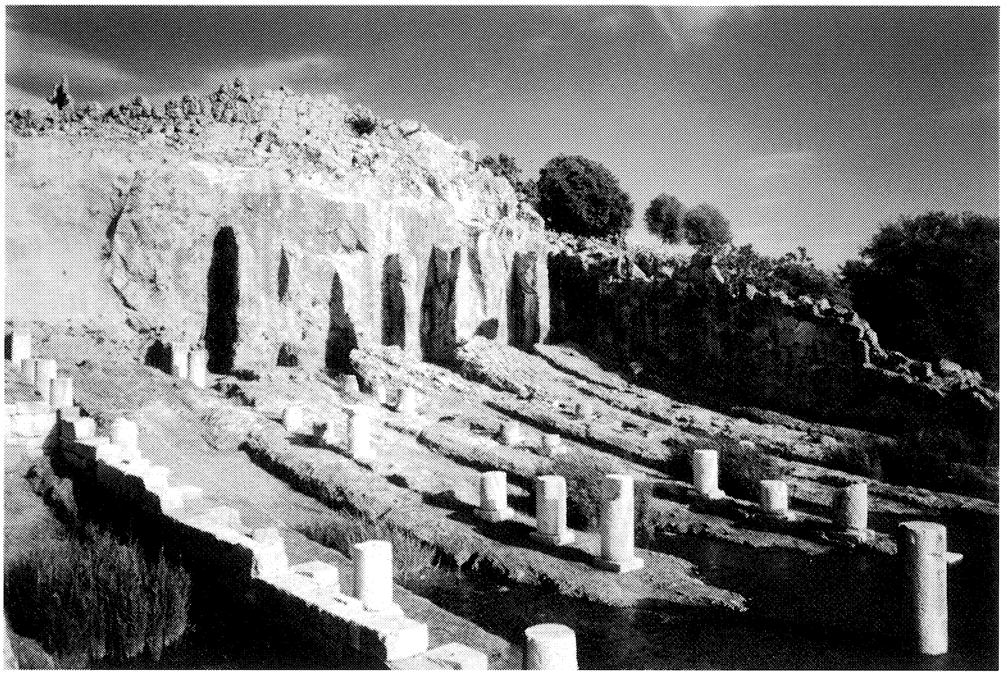
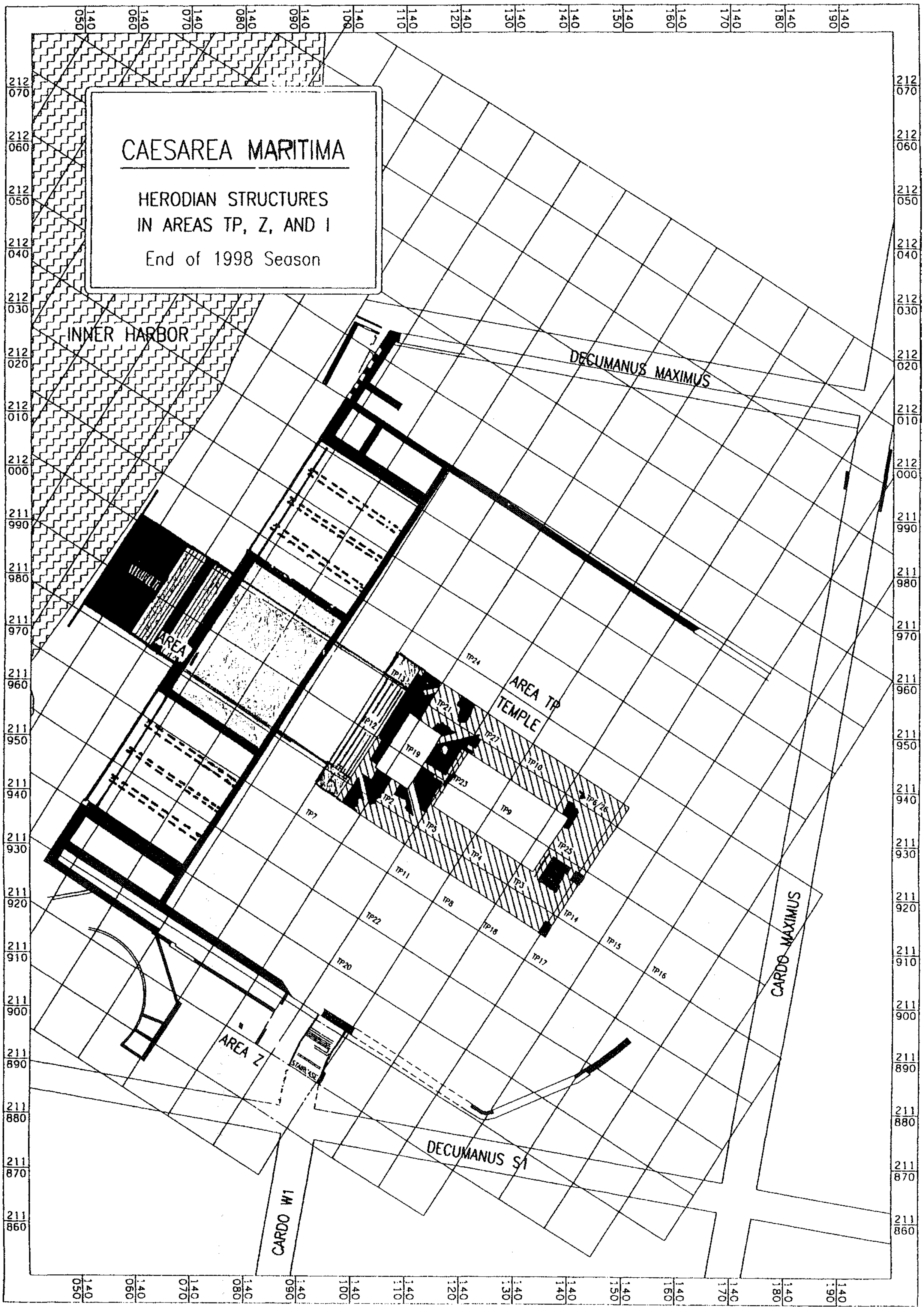


Fig. 15.7. The shipsheds at Oiniadai (photo: A. Raban).


CAESAREA MARITIMA
HERODIAN STRUCTURES
IN AREAS TP, Z, AND I
End of 1998 Season
INNER HARBOR
DECUMANUS MAXIMUS
AREA I
AREA TP
TEMPLE
TP24
TP13
TP21
TP12
TP27
TP19
TP10
TP23
TP2
TP6/26
TP9
TP7
TP5
TP4
TP25
TP11
TP3
TP8
TP22
TP18
TP14
TP15
TP17
TP20
TP16
CARDO MAXIMUS
AREA Z
STAIRCASE
DECUMANUS S1
CARDO W1
140 050
140 060
140 070
140 080
140 090
140 100
140 110
140 120
140 130
140 140
140 150
140 160
140 170
140 180
140 190
212 070
212 060
212 050
212 040
212 030
212 020
212 010
212 000
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211 910
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211 870
211 860

Fig. 15.8. Schematic top plan of area TP during Herod's time (drawing: A. Raban, A. Yamim).

fit the demanded seaward gradient at elevation higher than the retaining courses at the chambers' front. Ambiguous as is at the present stage of field research, these chambers have close resemblance in dimension to the slipways at nearby Dor.

The southern horrea is a series of four parallel vaults (Figs. 15.5, 15.9) facing the seashore by the bay just south of Sebastos, between its inner basin and the "Hippo-Stadium", the Amphitheater to which Josephus refers in his description of Herod's city (Jewish Antiquities, 15, 341; see also Porath, 1995). These vaults been designated as the "western vaults" by their excavator J. Patrich (1999: 90–93 and bibliography), marked from north to south as Nos. 1, 2, 11 and 12. At their original form, dated by Patrich to late 1st century AD they were *ca.* 32 m long; 6 m high (from bedrock to the inner crest of the vaulting, and 4.85 m (vault 1), 5.45 (vault 2), 5.65 (vault 11), and 5.30 (vault 12) wide. Arched openings, near the inner end of their lateral walls provided access between adjacent vaults. Vault 1 was excavated during 1973 and 1974, by the Joint Expedition and was dated to be originally an Herodian structure that had been subvented to *horreum* in the late 1st century AD; to a Mithraeum – in the 2nd century; and again, as *horreum,* from the 4th century on (Blakely, 1987: 38–39, 149–151). Patrich claims that the *horrea* usage is quite improbable for vaults that in their original phase were open to the west, without closing walls at their seaward ends (Patrich, 1999: 92). The lateral walls of all four vaults went through sequence of modifications, with the original phase of the actual vaulting been established no later than *ca.*100 AD (Patrich, 1999: 99). Yet, the fill between the external springers of the vaults contain sherds dated no later than Herodian period (late 1st century BC) and there are ample architectural remains of earlier walls in all four vaults, based on the bedrock which may be attributed to Herod's time (Patrich, 1999: 91). The western facade of CC *insula,* at the southern flank of these vaults contains remains of typical Herodian stucco (Lehmann, 1999: 139–142, fig. 4) – an additional data for attesting an original Herodian date for the western part of the complex. The limited areas of probes within these vaults that did reach the bedrock does not permit detailed and accurate reconstruction of its exact layout during the Herodian period. From the limited data one cannot trace any seaward inclination of the bedrock, or of the earliest floors. Yet, being at the waterfront the open elongated chambers are excellent candidates for shipsheds, even if their location is off the enclosed configuration of the harbour of Sebastos.

So, from the historic documents, the numismatic data and the archaeological information, one cannot attest any naval use in Sebastos, nor refute it, at the present state of

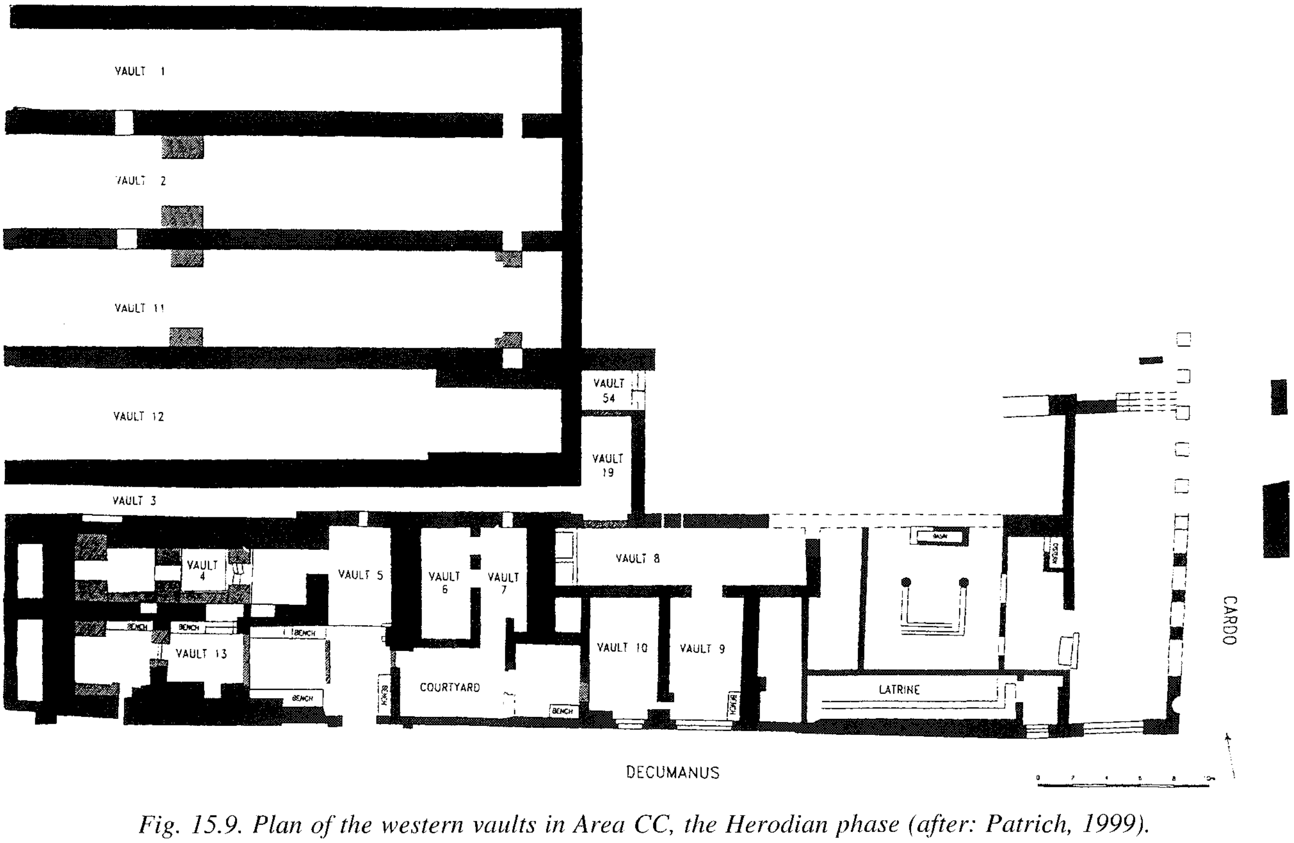

Fig. 15.9. Plan of the western vaults in Area CC, the Herodian phase (after: Patrich, 1999).

research (Fig. 15.10). Deducing from other major harbours of the period and the imperial ones in particular, one may find parallels to both cases – exclusive naval bases, such as those of the Roman *classis* at Misenum, near Puteoli; Ravenna, in the northern Adriatic; Cyzicus, in the sea of Marmara; Trapezus, in the Black Sea; Pompeiopolis, in Cicilia; Seleucia, in Syria; and naval, or military basins within the overall complex of commercial harbours, such as the famous one in Carthage; Forum Julii, in the Narbonesis (Provence); Piraeus; Apollonia, in Cyrenaica; Alexandria; Phaselis, and many others. Of interesting comparison is the naval station of the Roman fleet at the harbour of Caesarea Mauritania, a city rebuilt on a site of a former Phoenician settlement, by King Juba II, a contemporary of Herod and also a client King of Augustus (see Levine, 1975: 13–14; and much more details at Starr, 1993: 117–119). As for naval units, or temporary naval stations, in typically commercial harbours, such as Ostia and Puteoli we can learn from many historical sources (see Meiggs, 1973: 302–303).

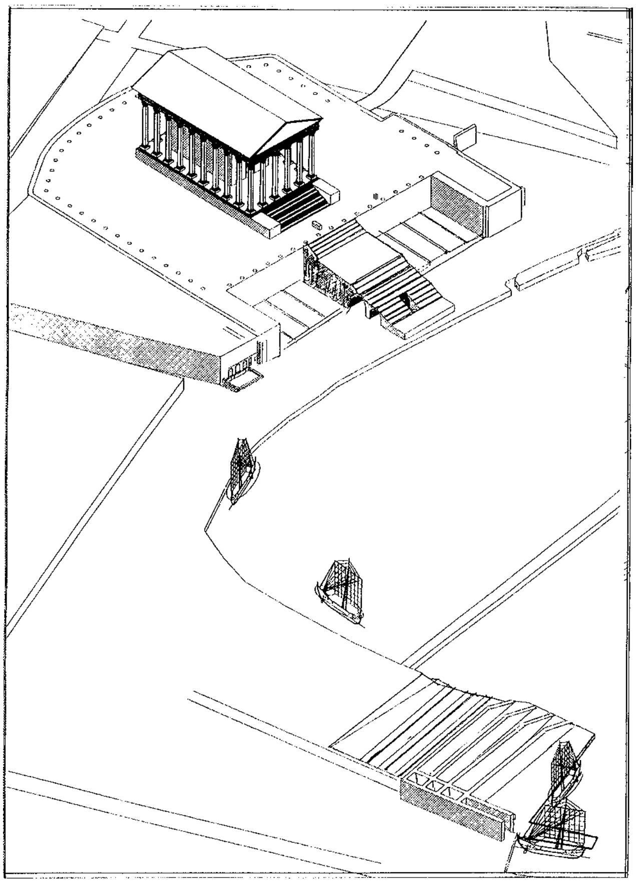

Fig. 15.10. Computerized reconstructions of the SE corner of Sebastos (drawing: A. Yamim).

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16. Operating on Shipsheds and Slipways: Evidence of Underwater Configuration of Slipways from the *Neosoikos* of 'Trypiti'

Kalliopi Baika

Ancient launching and hauling on shipsheds is not yet fully understood, though in antiquity it was considered a routine and established procedure for the protection and maintenance of warfleets. Especially, reconstruction of the timber furnishing and the mechanics of handling ships upon them depend mainly on the architectural configuration of ancient shipsheds, either rock-cut or stone-built ramps. New evidence of the underwater configuration of a slipway near Seteia can now add to our knowledge and help towards tempting more precise reconstructions of operational systems and establishing dry lengths.

Situated on the promontory of 'Trypiti', 3 km east of the bay of Seteia in NE Crete, the neosoikos is a single rock-cut slipway inserted in the fortification walls of the hellenistic city recently excavated on the hilltop of the promontory (Papadakis, 1988: 561–562; 1995). The first archaeological study of the installation was carried out in 1967 by C.Davaras (1967), who conducted a small-scale excavation in the upper part of the slip in order to remove the earth fill and debris, but undertook no underwater survey. The shipshed consists of a deep rectangular cutting into the bedrock in the SE hillside of the promontory, since strong prevailing N-NE winds and currents, which set from the open sea, forbade any other orientation of harbour installations. The cutting is about 5 m deep, almost 40 m long and has a clear width of *ca.* 5.5 m (Figs. 16.1–16.3). The gradient of the slipway is very steep (15° 30'), comparable to that of the shipsheds at Sounion (15° 50').

Despite the bad preservation of the slip's bedrock, which is almost entirely weathered away, several architectonic features left on the bedrock that need further investigation reveal traces for the installation of timber infrastructure. For example, a pair of corresponding longitudinal slots on the upper part of the slip could have been intended as a fixture of a pair of vertical timbers. Similar evidence has been reported from Kition and certainly exists in Oiniadae. In both cases, they consist of quadrangular slots set in some height on the dividing walls on the upper part of the slipways (Sears, 1904; Yon 1993: 40–41). Though the evidence is not conclusive, they could be fixtures for the installation of cranes, of structures for fastening ships or of hauling gear. Moreover, at the lower end of the slip, a large side cutting in the rock perpendicular to the ramp, which nearly corresponds to the slip's width was thought by Davaras to have held a

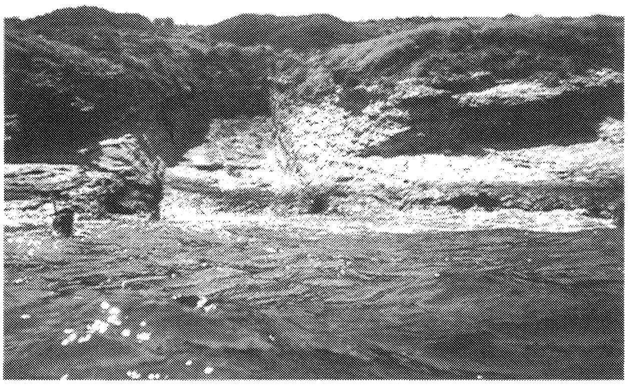

Fig. 16.1 Trypiti, neosoikos *from East. In the hill top remains of the Hellenistic city.*

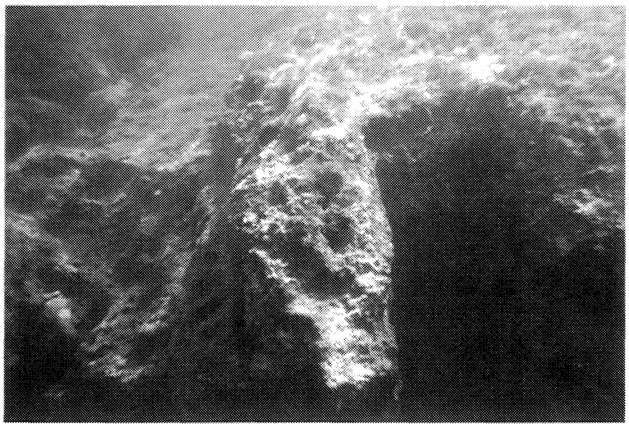

Fig. 16.2 South underwater ledge. First notch from East.

timber structure in order close the slip once the ship had been hauled in (Fig. 16.2).

However, the most characteristic feature of the neosoikos is the evidence of the underwater continuation of the slip's configuration. A preliminary underwater survey revealed the continuation of the artificial cutting of the slipway below present sea level. The slip's floor is prolonged into the water for about 2 m, where it is cut off. About 3 m seawards from the eastern edge of the large side cutting, an underwater ledge lies along both edges of the neosoikos (Fig. 16.2), where symmetrical rectangular notches arranged in two groups of four are cut deep into the bedrock (Figs. 16.5–16.6). The underwater pairs of slots are spaced at regular intervals of 1–1.10 m. The niches are 0.40–0.45 m wide and deepen gradually towards the open sea (depth of slots on south ledge varies from –0.60 m to –0.95 m, while on north ledge from –0.45 m to –1.10 m). The south ledge is more shallow and thus its surface is submerged from –0.45 m reaching –0.75 m deep. The aligned disposition of the slots indicates that they were probably intended to hold wooden cross-sleepers that would have formed a timber groundway extending seawards that slopes from –0.30 m to *ca.* –1.70 m (not allowing for the thickness of the

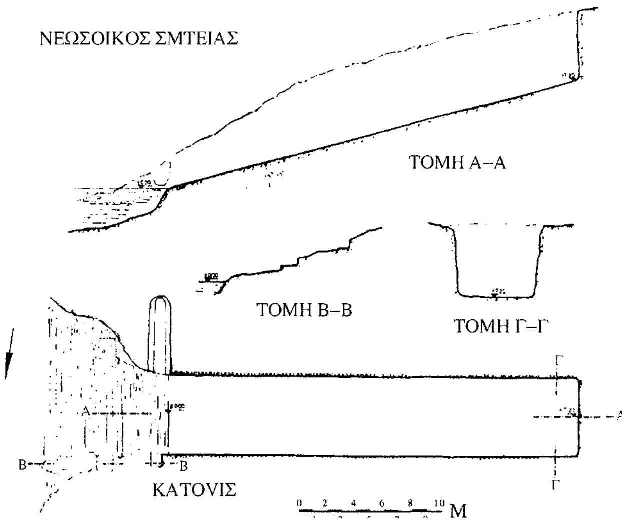

Fig. 16.3 Plan of the neosoikos *(after Davaras, 1967, fig. 2).*

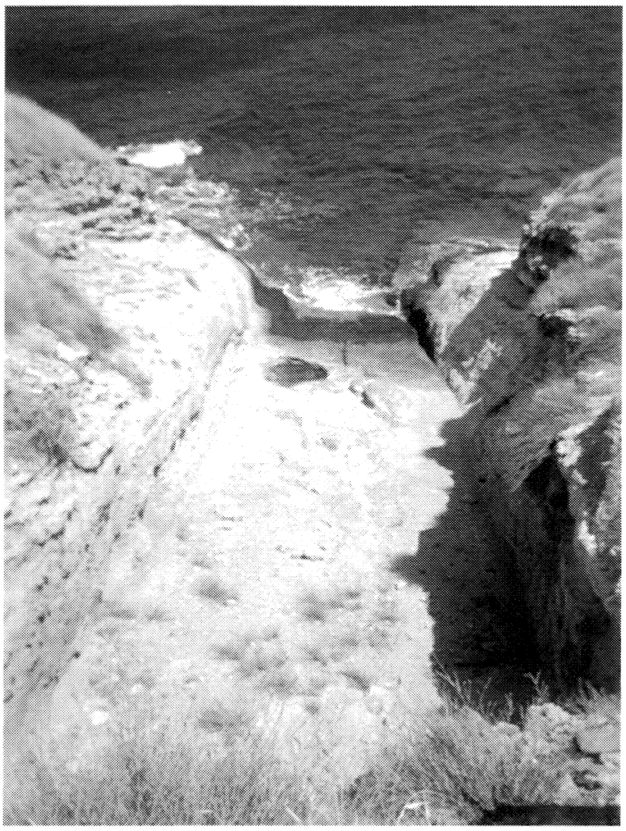

Fig. 16.4 Neosoikos *from West.*

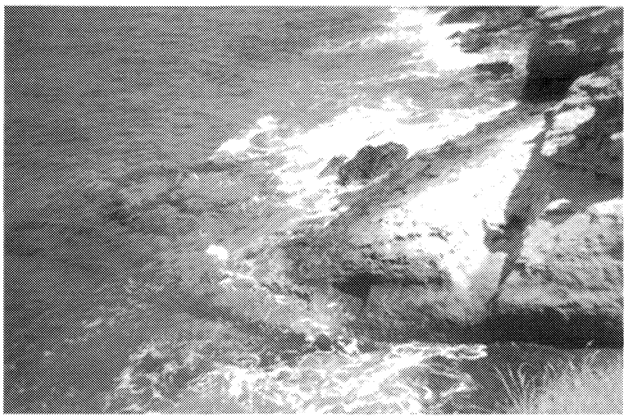

Fig. 16.5 Lower south part of the slipway. Large side cutting (door?), south underwater ledge, south group of underwater slots.

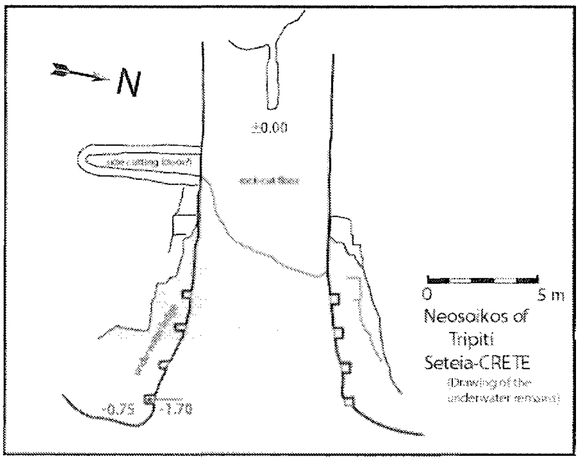

Fig. 16.6 Preliminary drawing of the entrance of the neosoikos.

wooden beams) below present sea-level with a gradient of almost 1:4.5.

Consequently, the wooden cladding would have been in continuation of the sloping rock-cut ramp, the total submerged length in inclination being at least 11.50 m from the eastern edge of the side cutting, presenting nearly the same declivity. But was it intended to be submerged? Generally, the determination of the underwater length of slipways remains a serious problem, especially since the question of the end of the shipsheds' ramp does not seem to have been fully borne in mind during most of older excavations (Coates, 1999). However, on launching operations the hazard of tipping and excessive bending of the hull of a ship depends greatly on the underwater length of the slip (Coates, in press a, in press b).

Certainly, one of the major problems in establishing dry lengths remains the determination of the relative sea level change since antiquity. Evidence of sea level variations in Crete since the Hellenistic period is not conclusive, though it is argued that the island suffered a severe tectonic deformation within historical times and a general sea rise reached its peak in the North-eastern part of Crete (Hafemann, 1966: 669–686; Flemming *et al.*, 1973; 1986; Pirazzoli, 1991: 88–99) (Fig. 16.8). In the Seteia bay, submerged ruins of rock-cut fish tanks of Roman period (by about 1 m) (Davaras, 1974) and of an Early Byzantine basilica also indicate a plausible submergence by 1–1.5 m.

Consequently, the wooden skidway would have been partly submerged extending for about 5–6 m into the sea in order to provide for a controlled landing. Considering the extremely exposed location of the installation to waves and the open sea we must certainly allow for a distance of at least 3–4 m of the bow of the ship from the water's edge when hauled up. Only based on that assumption, can the large side cutting of the seaward end of the shipshed actually be a kind of an enclosure, as Davaras has been suggested (1967: 88–89). Thus, we are left with an original dry length of about 28–29 m. We should also take into account that the declivity is not homogeneous along the length of the slipway, but starts *ca.* 3.50 m from the back wall and runs for 27 m until the western edge of the 'enclosure's edge.

Moreover, the whole operational system must be studied in association with the large immersed slots on the sides of the neosoikos. Davaras (1967) described two pairs of apparently corresponding slots in the seaward edge of the slip. A third one of similar dimensions is to be observed at the seaward end on the east. Similar niches, that need further study, are to be observed at the seaward ends of the neosoikoi of Matala and Rethymnon, and may have held timber bligeways intended to provide the vessel lateral support during hauling out.

The closest parallel of the slipway of Trypiti is the pair of smaller and narrower, but equally steep rock-cut slips on the inner north side of the promontory at Sounion (Kenny, 1947; Goette, 2000: 48–49). Here, the dry length is reported to be 20.50 m with a further 6 m in the water. In fact, the ledges of the slips stop at the entrance of the rock-cut chamber while the deep cuttings of the rock floor continue about 6 m into the water 'to enable vessels to be drawn up without running their keels aground' (Kenny, 1947: 196). Coates (1999: 111) wonders whether these deep (0.70 m) keel cuttings are intended to reduce the necessary underwater length of the main slip floor, while he argues that the reported 6 m underwater length 'is remarkably, even implausibly, generous'. Here, as in Trypiti, ancient sea level is not securely established and therefore estimating an adequate depth of about 0.70 m for the bottom end of the keel groundway, he suggests a relative sea level rise of 0.3 m. In Trypiti, even assuming a considerable sea rise (1.5 m) the underwater length of the slip is about 5–6 m, though more precise measurements in underwater level are to be done.

The timber cross-sleeper structure of Seteia clarifies a part of the operational system of ancient slipways and especially as far as the underwater prolongation of the slip is concerned. Such evidence is rare. However, wooden cladding of slipway ramps, either stone-built or rock-cut, protected the ship's hull from direct contact with the stone-structure. It is now widely accepted that ships were hauled up slipways either running their keel-ups directly – as can be deduced from the evidence of Naval Lists of the Athenian Navy (Blackman, 1990) and the ancient sources referring to an external fitting for keels (χέλυσμα-*chelysma*) attested also on shipwrecks (Theophrastus, *Historia Plantarum,* V.7.2; Steffy, 1985: 89, 97; Amigues, 1990; Kahanov, 1998: 156) – or plausibly they were supported by longitudinal cradles, central keel-runners, simple greased cross-sleepers or a combination of the above methods.

Cross-sleepers correspond in all probability to ancient φαλαγγαι *phalangae* (Baika, in press), the use, dimensions and disposition of which derive in detail from the account of Athenaus (*Deipnosophistai,* 5.204 c–d) of a dry dock in Alexandria designed specially by a Phoenician engineer in order to launch the 'forty' of Ptolemy. On that occasion, the *phalangae* were set at regular intervals throughout the length of the slipway and measured 1 cubit in height (= 0.49 m): φαλαγγας επικαρσιας κατα πλατος της ταφρου διωσας συνεχεις τετραπηχυν εις βαθος τοπον απολειπουσας After the launching had been completed the vessel set safely on the traverses: ηδρασθη το πλοιον ασφαλως επι των προειπημενων φαλαγγων

Accordingly, Polyaenius (5.2.6) describes a spectacular transport of ships on land after setting down on the muddy earth of 20 *stadia*, *phalangae*: τοπος ην ομαλος και πηλωδης, ευρος εικοσι σταδια τουτον οι στρατιωται ξυλοις υπερηνεγκαν ογδοηκοντα τριηρεις ημεραι μιαι.

In Trypiti, deducing the dimensions of the sleepers from the slots, the *phalangae* would have been square wooden beams of considerable dimensions forming a rigid and robust skidway solid enough to withstand the first impact and ease the landing of the rising keel at the stern during hauling out. Their dimensions and especially their width (0.45 m), almost of one cubit, considerable compared to archaeological parallels (Tab. 1) are easily explained by the fact that the timber structure was intended to form a slide plan in steep declivity without resting on ground soil or bedrock. In Kos, for example the sleepers are much smaller but they are reposing on central stones, that are intended to hold the strain of the keel (Kantzia, 1987) (Fig. 16.7).

Archaeological parallels for the installation of timber infrastructure on slipways can be traced throughout the Mediterranean (Tab. 1). Niches and slots as settings in masonry for timber cross-sleepers have been found on the inner side of the stone side ramps of Rhodes (Blackman *et al.,* 1996: 400–401, figs. 14, 16, 27–28), possibly also on the shipsheds of Naxos in Sicily now under excavation (Blackman, in press), while on Thurii there are clear evidence of settings for a timber grid (Zancani Montuoro,1972/73). Slots cut at regular intervals of 1 m on the lateral walls on the 'careening ramp' of Apollonia would have probably formed an elevated skidway, very similar to Trypiti's, but immersed (Flemming, 1971: 110–111; 174, fig. 68, C5). Nevertheless, the closest parallel comes from the harbour installations of Kos, where a shipshed of Hellenistic period of standard trireme type has well cut slots in opposed pairs on the inner side of stone courses running down within the full width of the shipshed (Fig. 16.7).The inserted timber sleepers were supported by stones with cross-cuttings mid-way, where the structure holds the strain from the keel, and would have thus formed a timber-cladded ramp of a standard 3 m width (Kantzia, 1987: 632–635, pls. 355–357).

Moreover, actual remains of *phalangae* set at regular intervals were revealed *in situ* in the shipsheds of Carthage, and the recently excavated harbour complex of Marseille. In particular, in the naval complex of Carthage charred remains of parallel timber sleepers set at regular intervals were revealed *in situ* and possible traces of longitudinal timbers intended to serve as guides for the hulls of the ships or timber cradles were also reported (Hurst, 1979: 30, pl. VIIIa–b; Hurst, 1994: 17–18, fig. 2; Gibson in Hurst 1994: 33, figs. 2.1, 3.2, 12.2–3, pl. 2a). Accordingly, trenches for the installation of central longitudinal keel-runners and associated smaller traverses were excavated in the roman shipsheds of Haltern-Hofestatt (Morel, 1987), while traces of timber *phalangae* underlying a single longitudinal rail are equally reported in a early roman boatyard at Mainz (Höckman, in press).

Finally, new evidence is provided from the recent excavations on the Hellenistic harbour installations of Marseilles. Open slipways and shipsheds of the 3rd and 2nd century BC are equipped either with cross-sleepers set on the beach or mobile timber rollers set on the beach. The arrangement of the operational devices is evocative, while the fixed timbers even show traces of ships keels

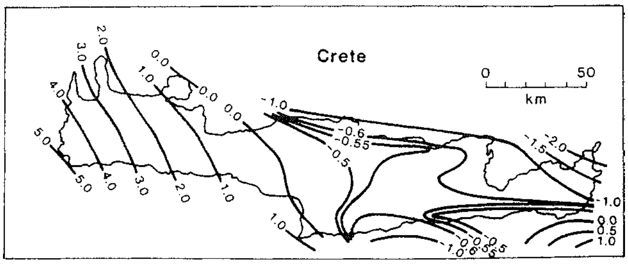

Fig. 16.8 Plan of Crete. Profiles and rates of vertical earth movements (after Flemming, 1986: 21).

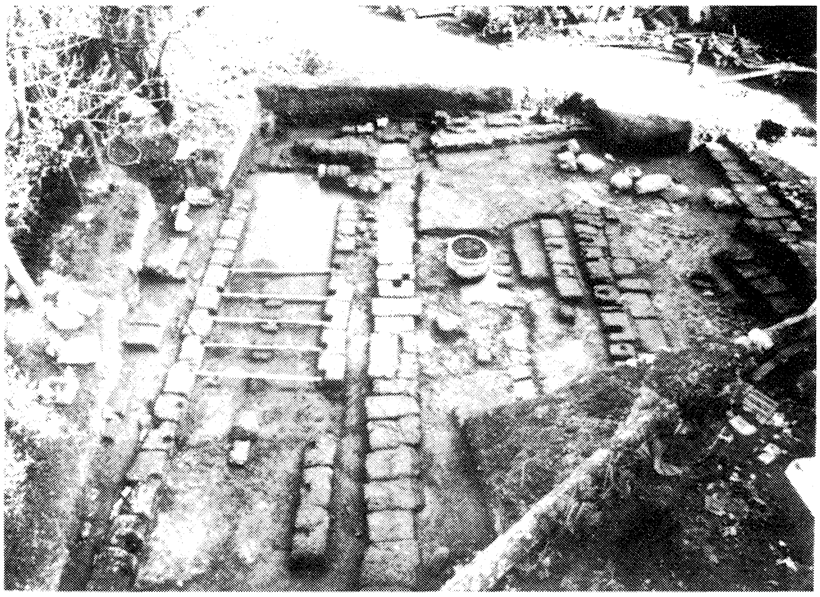

Fig. 16.7 Neosoikos *of Kos and improvised reconstruction of the wooden cladding (after Kantzia, 1987, pl. 357).*

(Hesnard, 1994: 205–206, fig. 6; Hesnard *et al.,* 1999: 21–41, pl.II; Hermany *et al.,* 1999: 125–130).

The simple and evocative configuration of an open slipway that consisted of a skidway leading to a slip equipped with central keel blocks and the chocks of the shores *in situ* gives an idea how temporary naval bases (ναυσταθμοι of ancient fleets should be reconstructed. They almost certainly correspond to the υπαιθριοι νεωσοικοι (*open shipsheds*) of the Naval Lists of the Athenian Navy and maybe also to the ψυκτρας τας προς τοις νεωριοις του λιμενος known from inscriptions of the 1st century B.C. (IG II/III2 1611, 6–7; IG II/III 2 1035, 43–46). Generally, timber cladding either simple *phalangae* forming skidways or timber cradles to support the strain of the keel, is to be expected as standard equipment of a *neosoikos*. Archaeo-ethnographical studies can demonstrate their similarity with common operational devices of modern traditional shipyards throughout the Mediterranean (Baika, in press).

Typologically, the slipway of Trypiti enters the category of rock-cut slips, mostly single ones, that groups the neosoikoi of Sounion (Kenny, 1947), Alimnia (Blackman, 1999), Matala (Blackman, 1973), Pyrrha, Rethymnon, Antikythera and Dor (Raban, Linder, 1978) almost all of Hellenistic date and probably intended to house ships inferior to the dimensions of a classical trireme.

In Trypiti, we are dealing with a relatively wide and short slipway with length: beam ratio of nearly 1: 4.7. It has already been suggested that the length:beam ratio may have been different in some Hellenistic warships from the Classical trireme and Casson may be right in supposing that they could have been broader than we normally assume (Casson in Blackman, 1999: 119, n.10). Accordingly, Coates' tentative design studies of small warships, especially the hypothetical reconstruction of *two-level pentecontors, hemioliai* and liburnians indicated ships of about 4–4.5m breadth overall and lengths of about 20 to 25 m. In addition, the light drafts of those warships do not require a depth of more than 0.65 m and 5 m underwater length of harbour installations, measurements that correspond quite well to our evidence (Coates in Morrison, 1996: App. D).

Consequently, in the Trypiti's shipshed as in Sounion, only small warcraft were to be accommodated and not full-sized triremes or higher denominations of Hellenistic warships. After all, the fortified and strategic location of both promontories justifies the concern to have a fast and manoeuvrable light warship always ready to be launched in case of emergency or attack from the sea. Knowing the piratical role of Crete in Hellenistic times (Ormerod, 1924: 225–226, 28–31; Brulé, 1978; Chaniotis, 1996; de Souza, 1999), we can safely imagine one or two level warships: myoparones, triacontors or *pentecontors, lemboi, hemolia, keles* or liburnian type ships, vessels widely used by pirates in the Mediterranean during all the Hellenistic period.

Moreover, particularly considering the strategic emplacement of the naval base, we can assume a guard ship φυλακιδα ναυ (Diod. Sic., XX, 16.5) or a κατασκοπος ναυς *kataskopos naus* (Plut., *Pomp.*, 64.1; Plut., *Lys.*, 10.3; Plut., *Cat. Min.*, 54.5; Caesar, *Bell. Afr.*, 26.3: *catascopum*) or *speculatoria navis* (Livy, 36.42.8). As Casson (1971: 123–135; 160–161) points out, navies, as a rule, main-

	TRYPITI	**CARTHAGE R16**	**CARTHAGE F762**	**RHODES**	**KOS**	**APOLLO-NIA**	**THURII**	**LIPPE (W ramp)**
Total width of slipway	5.5m	5.30 excavated length: 28m	5.30	7.34–6.85 5.44–4.95	5.50m	4m	6.20m	6.48m
SLOTS	On lateral walls of underwater ledge	Slots and timber remains on the ramp floor	On the ramp floor	On the side ramps	On the inner stone-ramp structure	On the lateral dividing walls	Forming a timber grid on ramp's surface	Trenches excavated on the ramp floor
Cross-section	*ca.*0.40×0.40m	0.10×0.15m	0.20m×?	15–20, 25cm	0.20×0.20m	0.15×0.15m	0.20×0.20m	
CROSS-SLEEPERS	Underwater-Elevated	On the ramp floor. Evidence of longitudinal timber.	On the ramp floor. Evidence of longitudinal timber.	On the ramp floor?	Set on stone ramp	Elevated from the bed floor	Inserted on cobbled ramp. Associates w/longitudinal timbers.	Lateral traverses set on longitudinal timber keel-support
Length	*ca.*5.80m		1.7–1.8m	3.80m	2.9 – 3m	Slipway's length	6.20m	3.35m
Interval	1–1.10m	0.6–0.7m	*ca.*1.7m	irregular	0.80m	1m	*ca.*2.25m	2.32m
Declivity (of slipway)	15°30	1:9.5 1:7	1:6 1:20	1:4.62 1:4.36	1:5,67	4°	2°	?
Date	Hellenistic?	Hellenistic	Hellenistic	Hellenistic	Hellenistic	Hellenistic?	3rd century BC?	Augustean period

Table 16.1. Evidence of the installation of cross-sleepers on slipways

tained a good number of these types that designate any of the above mentioned smaller hellenistic craft when employed for such duty.

Concluding, architectural evidence of underwater prolongation of the neosoikos of Trypiti adds to the understanding of the timber infrastructure of naval installations and of the operational system of manipulating warships on slipways. Especially, single rock-cut slipways that are mostly intended to house certain types of vessels can help towards determining dimensions of smaller hellenistic warcraft and clarify the function of small-scale naval bases.

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17. An Early Roman Boatyard at Mainz, Germany

Olaf Höckmann

We are used to think of shipyards as of vast, and conspicuous plants for the construction of huge steel ships. It should not, however, be neglected that at the same time there exist many humble yards for the construction of small wooden vessels, which are as inconspicuous as hardly to be discernible but at a close distance. A few centuries from now, only few traces would offer themselves to excavators, namely numbers of nails or rivets, perhaps some lost tools, and lots of more or less decayed wood chips, and sawdust.

The number of ancient representations of ships being built is restricted. Well known is a Roman tombstone from Ravenna the relief of which shows the shipwright *Publius Longidienus* moulding a frame by the adze in front of a hull (Casson, 1971: pl. 163; Göttlicher, 1985: fig. 66; Höckmann, 1985: fig. 133; Pekáry, 1999: 234, I-R-2). The yard itself, and its surroundings are not indicated.

It will have been like the one shown in a panorama of the city of Cologne, from AD 1531 (Kranz, Alertz, eds., 1993, II, unnumbered fig. "1"). On a small island in the river Rhine, ships are being built, or repaired. The "yard" is not marked by any permanent constructions. Next to it cattle are browsing. This likely is how we should imagine shipyards of antiquity. An excavator of now is rather likely to dig right through them without noticing it unless being attentive to rather inconspicuous observations. Let me present an example for potential results, and their limitations, gained during a rescue excavation at Mainz, Germany, in 1998.

When from 16 BC on, the first Roman emperor, Augustus, set his mind to putting an end to the recurring inroads of fierce Teutonic tribes from now NW Germany into the Roman province of Gaul, he chose two places for forming the bases for future Roman offensives against so-called Free Germany, north of the Rhine. These are *Vetera Castra* near Xanten, on the Nether Rhine, and *Mogontiacum* – now Mainz-, on the middle course of the river (von Schnurbein, 1986: fig. 3). Both places are opposite the mouths of larger tributaries, namely in the case of Xanten, the river Lippe, and in the case of Mainz, the river Main, which evidently were conceived to form the highways for Roman operations in the enemy's country where no efficient roads are likely to have existed.

In the course of these operations, the Romans later founded several legionary camps along the river Lippe, among which the one at Haltern, founded *ca.* AD 5 and destroyed in AD 9, stands out. At this camp there arose such installations as potters' workshops which produced a special type of Samian ware, *Haltern Sigillata.*

It has been found at a number of Early Roman sites along the Nether, and also the Middle Rhine, which testifies to river traffic having existed among these Rhenish places, and Haltern (von Schnurbein, 1986: fig. 3).[1] The southernmost finds of *Haltern Sigillata* now known derive from Mainz.

In the autumn of 1998, a large construction site at the south border of the city, close to the Roman-age bank of the river Rhine, necessitated a major rescue excavation by the State Archaeologist, G. Rupprecht, who kindly invited me to have an eye upon the excavation, and publish its results. I sincerely thank him for both.

For reasons of local topography, the site might have included shipsheds for Roman warships of the Rhine flotilla. Moreover, the tombstone of a nameless shipwright from Mainz, Oberlaubenheimer Weg, dated *ca.* AD 40 (Höckmann, 1997: fig. 4.1), shows a warship of Mediterraean type together with shipwright's tools, implying that a Roman shipyard also might have existed on that site.

Roman warships used to be stored in shipsheds whenever not operational, no matter if in the Mediterranean or on the northern frontier of the Empire. At Haltern, a group of eight wooden sheds was found on the ancient bank of the river Lippe (Morel, 1987).[2] There are seen long central "rails" crossed by short sleepers. Such features will occupy us soon. Shipsheds can be expected at every Roman naval station, as Mainz was (Höckmann, 1986: 370, 379). The excavation at this potentially crucial site made me eagerly comply to Rupprecht's invitation.

The site had earlier been a Celtic settlement of fishermen or river traders, which might have lent its Celtic name to

Roman Mogontiacum. The Romans then terraced the sloping site for the use they intended. On the lower terrace there came to light an astounding number of large worked timbers, many of which lay more or less parallel to the river bank (Fig. 17.1, 1), *ca.* 70 m distant at low-water conditions.

This very level is by finds of *Haltern sigillata* among the timbers dated to the years AD 5–9, which puts it into the context of Augustus' operations in NW Germany.

Among the timbers there are two oak planks of which *ca.* 4 m were preserved lying in line (Fig. 17.1, 2). The left end being broken, the original overall length is unknown. The structure will henceforth be called the "rail". Both parts are by notches in their lower sides connected to short cross sleepers of rectangular cross-section (Fig. 17.1, 2: black). One of them had at its eastern end been secured to the soil by another timber. This supports the idea that the lathes were meant for holding the plank in place under lengthwise stress. Not all sleepers had been secured to the "rail" on top (Fig. 17.1, 2).

This very combination of a "rail" underlaid by sleepers, is characteristic of the shipsheds at Haltern (n. 2). It is certain that the central rails were meant for supporting the keels of warships when being shoved into the sheds, and when resting there.

At Mainz, there is no hint that the "rail" formed part of a shipshed. No trace of a building was found, and moreover the orientation of the "rail" would have been inconvenient for a shipshed. The "rail", rather, formed a building berth in a boatyard.

This notion is supported by the fact that the shipyard level was embedded in a layer consisting of wood chips, and sawdust, including thin branchlets, which by their resin and loam had assumed a consistence similar to modern fiberplate. In the excavation, it sometimes had to be broken up by the pickaxe. The shards kept their consistence for weeks when lying on the dump. The evidence leaves no doubt that large amounts of timber had been worked at the site, which is corroborated by the find of a socketed iron chisel, and a bent fragment of a sawblade. The compact homogeneous consistence of the wood-chip layer seems to indicate that there had not occurred a major interruption during the period of woodworking.

No installations for supporting tree trunks while being cut have been found. If sawing was done as it was in Greece in the early 20th century, permanent installations were not necessary. In Greece, one end of the trunk was lifted onto an improvised bipod of crossed beams, one member of the sawing gang standing on the trunk, and the other below.

Some timbers found near the "rail" may be attributed to ships. Lacking mortises or nail holes, they cannot form part of finished ships. In the upper surface of a thick oak plank (Fig. 17.1, 3), there are three rectangular indentations, and two square holes of identical size. Two of the former, and one hole are arranged at equal distances of 87.4 cm. This comes as close to the interscalmium of 2 cubits (88.8 cm) between rowers' thwarts, recommended by Vitruvius (I, 2, 4) (Casson, 1971: 53, n. 66), as to consider the timber to be a keelson, supporting rowers' thwarts by short vertical stanchions, as is seen on Roman boats from Vechten (Höckmann, 1994: fig. 1 B) or Oberstimm (Höckmann, 1989: fig. 4) (Fig. 17.1, 5).

Many timbers of rectangular cross section, *ca.* 40 – 75 cm long (Fig. 17.1, 4), some ending in tenons at one or both ends (Fig. 17.1, 4, left), may have been such stanchions. Their lengths would permit this function. Longer ones without tenons (Fig. 17.1, 4, right) may have served a multitude of functions.

A double-bent timber 1.46 m long, and a smaller one made to fit it snugly found next to each other, might form a sternpost ornament. It is too thin for having been a real sternpost. Parallels from the early 1st century AD, however, are not known to me yet. An obtuse – angled knee seems to form part of a composite frame.

It should be mentioned that no iron nails were found. This, however, does not form an argument against ship construction on the site. On Roman boats of Vechten type, frames were held in place by trenails (Höckmann, 1989: 328, fig. 7.2–3). At the Mainz yard none was found either.

There remains a problem about the shipyard. The "rail" namely runs *parallel* to the river bank, whereas a 90° position and lesser distance would seem more convenient for launching vessels built there. Such an awkward situation, however, is thought to have existed at the Danube castle of Schlögen, in Austria (Eckhart, 1969: 15, 37, 41, Beilage 1). Its excavator suggests that boats had been constructed or repaired in a building parallel to the bank, and then were somehow maneuvered toward the river Danube.

At Mainz there might be a chance that the "rail" was not oriented toward the river bank but an artificially excavated basin south of it, beyond the excavated area. During the hurried closing days of the rescue excavation, its leader Th. Dederer was present when the mechanical excavator destroyed a timber building which stood due south of the "rail". There does not exist a continuous profile connecting both features, but they were found at the same level, right on the natural subsoil in the case of the "rail", and in the one of the building, in narrow foundation trenches dug into the subsoil. For this reason both features can be attributed to the same period.

Dederer managed to achieve a kind of emergency documentation.[3] The building consisted of two parallel piers of square oak timbers resting on short sleeper planks, at a distance of *ca.* 6 m. They run E/W, for example at a right angle to the "rail" due north of it, and the bank of the Rhine, *ca.* 2 m apart from each other and the square posts, two parallel rows of round posts had been rammed into the gravel subsoil. The findings favour interpreting the building as a warehouse for storing grain, a *horreum*, the raised floor of which needed strong supports for carrying the weight of the grain stored. Some long timbers of coniferous

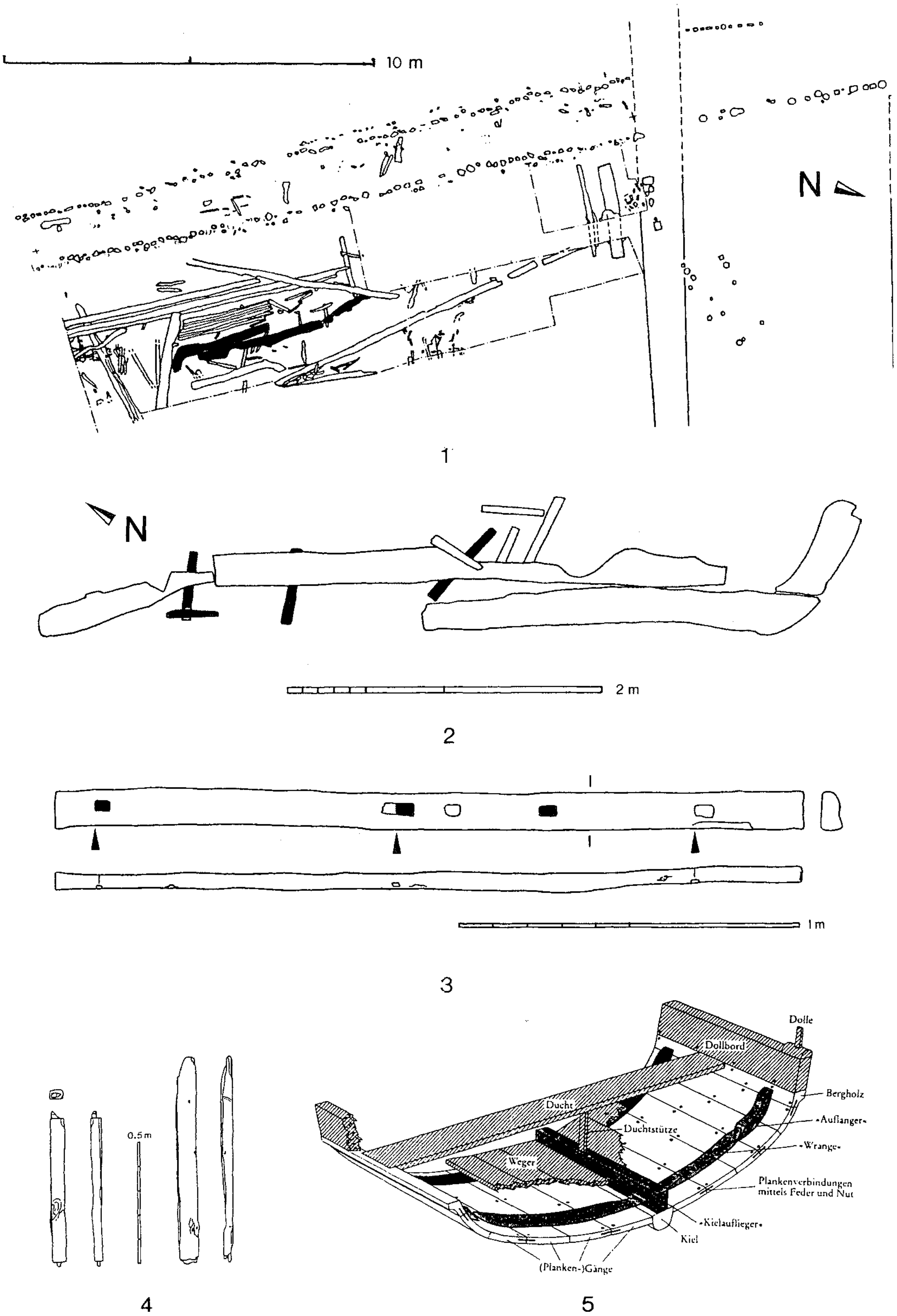
10 m
N
1
N
2 m
2
1 m
3
0.5 m
4
Dolle
Dollbord
Ducht
Bergholz
•Auflanger•
Duchtstütze
•Wrange•
Weger
Plankenverbindungen mittels Feder und Nut
•Kielauflieger•
Kiel
(Planken-)Gänge
5

Fig. 17.1 Mainz, Neutorstrasse. 1, Plan of the Early Roman section of the site. The boatyard complex is marked black (Landesamt fuer Archaeologische Denkmalpflege, Mainz); 2, The boatyard complex. Sleepers held by notches are markedblack (same source and author); 3, The keelson. Arrows mark the points definingequal distances of 87.4 cm (same sources); 4, Two smaller timbers. The left one, having tenons at both ends, is likely to have been a thwart support (same sources); 5, Oberstimm (Germany), section of boat 2 showing thwart supports (Duchtstuetzen) (author).

wood found right above the oak structures of the boatyard, are by Dederer thought to form remains of that building which was destroyed by a flood, leaving its trace by a thin deposit of layered fine sand covering the sawdust layer. Such warehouses use to run parallel to quays or a river bank at a short distance (for example, Riederer, 1982: fig. 89). It matters that the foundation trenches of the warehouse at Mainz are filled not by the yellowish subsoil gravel, but by grey loamy river silt. It shows that the Romans not only had terraced the yellow gravel subsoil of the boatyard but also had dug into a silted cove.

If the warehouse's position square to the river bank implies the same direction for a quay, there appears likely that immediately south of the warehouse, for example in the area not excavated, there had existed an artificial dock basin likely to have issued from a silted cove for serving the warehouse.

In theory, that basin might have preceded the warehouse, for offering direct access from the "rail" to open water. If this be correct, the warehouse should have been erected somewhat later within the short duration of the "yard" period, and only then blocked the access from the "rail" to the hypothetical artificial dock. The question only could be answered by dendro-dates from the timbers in the "yard" area, and the warehouse. For both, many samples were taken, but they have not been evaluated as yet.

There might be an alternative. Next to the "rail" there lay a massive oak plank extending into a shorter end at an obtuse angle (Fig. 17.1, 2). It would have been useful for turning boats built on the "rail" toward the river. Eventually, a group of parallel lathes *ca.* 2 m long carefully laid out next to the angular plank, might have aided that operation (Fig. 17.1, 1). The boats then might have been shoved toward the river on wooden rollers.

For summing up, there exists archaeological evidence for boats having been built in the area excavated in 1998. It does not hint at the existence of any permanent installations at this military yard, which only seems to have formed part of a plant where large amounts of timber were worked into planks or beams for all kinds of constructions. Some long coniferous timbers found there out of their original position, seem to have formed part of a warehouse for storing grain.

This period is confined to the few years AD 5–9, unless part of it. It still is uncertain if the adjacent warehouse existed simultaneous with the yard, or slightly later. The demise of it, and the yard was caused or accompanied by a flood which left its traces by thin layers of greyish yellow river sand right above the sawdust layer. No traces of the yard's having been reactivated after that flood were noticed. Perhaps the collapse of Roman rule in Free Germany in AD 9 caused changes in Roman river communications which for a while put an end to shipbuilding at Mainz, which only *ca.* AD 40 is certain to have been resumed.

The yard shortly later was covered by a massive fill of alternating thin layers of light yellowish clay, and dark brown settlement refuse. On it, linear pole constructions, likely to have been "dikes" for protection from high floods, were erected (Fig. 17.1, 1). They are beyond the scope of this paper, and will be published in *Mainzer Archäologische Zeitschrift.*

Notes

[1] The sites of Wiesbaden and Mainz are upstream of the treacherous river narrows the *Binger Loch* (Höckmann, 1986: 387–17; Konen 1997; 2001: 15), implying it was navigable during the Roman period.

[2] On the floors of Late Punic shipsheds on the *Ilôt de l'Amirauté* at Carthage, destroyed in 145 BC, there were excavated charred remains of wooden sleepers across the sheds, and perhaps part of a central rail (Hurst, 1979: 24, fig. 1).

[3] Dederer's commitments left him no time as yet for adding the warehouse to the general plan (Fig. 17.1, 1). My sincere thanks are due to him for oral informations, and the display of slides showing the warehouse complex.

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18. Essay to Restore the Operating Process of a Shipyard in the Early Medieval Period: the Example of the *Port Berteau II* Wreck, Charente-Maritime, France

Eric Rieth

Introduction

The *Port Berteau II* wreck site is situated in the lower part of the river Charente, near *Mediolanum Sanctonum*, the ancient town of Saintes, Charente-Maritime, at a distance of 65 km from the Atlantic coast (Fig. 18.1). In this section of the river, the power of the tide was still important before the building of the Saint-Savinien dam in the second part (1866–1881) of the 19th century, and made easier the relations between the maritime and the inland navigation. In the 19th century, merchant sloops and schooners went up the Charente to Saintes which was at this time the natural *terminus* of the coastal navigation.

The wreck and its reconstruction

From 1992 to 1997, the *Port Berteau II* wreck, which has the particularity to be preserved at a depth of 7 m in an inversed position on the bottom of the river, was excavated under the author's direction with the technical collaboration of the DRASSM (Research Department of Underwater Archaeology of the ministry of Culture). This excavation (Rieth, Carrierre-Desbois, Serna, 2001) was the last step of a long research programme of nautical archaeology to study the medieval water transport of the Charente in relation to the paleo-environmental context and the man-made structures in the bed and along the banks of the river (Rieth, 2000a).

The chronological data come from three radiocarbon dates and the dendrochronological study of 158 oak samples which only 43 were used in the last step of the analysis. The tests resulted in the construction of a dendrochronological average of 149 years. The comparison between this average and various curves of reference indicate that these oaks were felled during the winter 599 AD. The building of the ship could be dated to the year 600 AD and the shipwreck to the beginning of the 7th century.

In relation to an ancient depth of the Charente of between 1.50 and 2 m, the analysis of the archaeological remains and stratigraphical profiles suggests how the vessel may have been wrecked. It seems possible that the ship was laid up on the right bank of the river, near Port Berteau, and that its loss was the result of a flood. The fact that the ship was laid up for repairs could explain the absence of rigging and steering elements and archaeological artefacts.

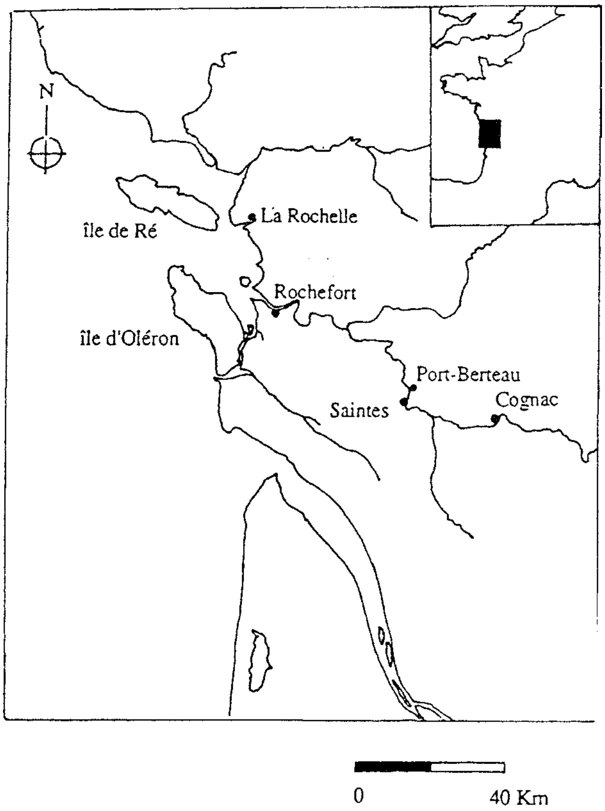

Fig. 18.1. Location of the Port Berteau II *wreck.*

The archaeological characteristics indicate, first of all, that the architectural structure of the hull is connected to a maritime tradition of shipbuilding (Fig. 18.2). Indeed,

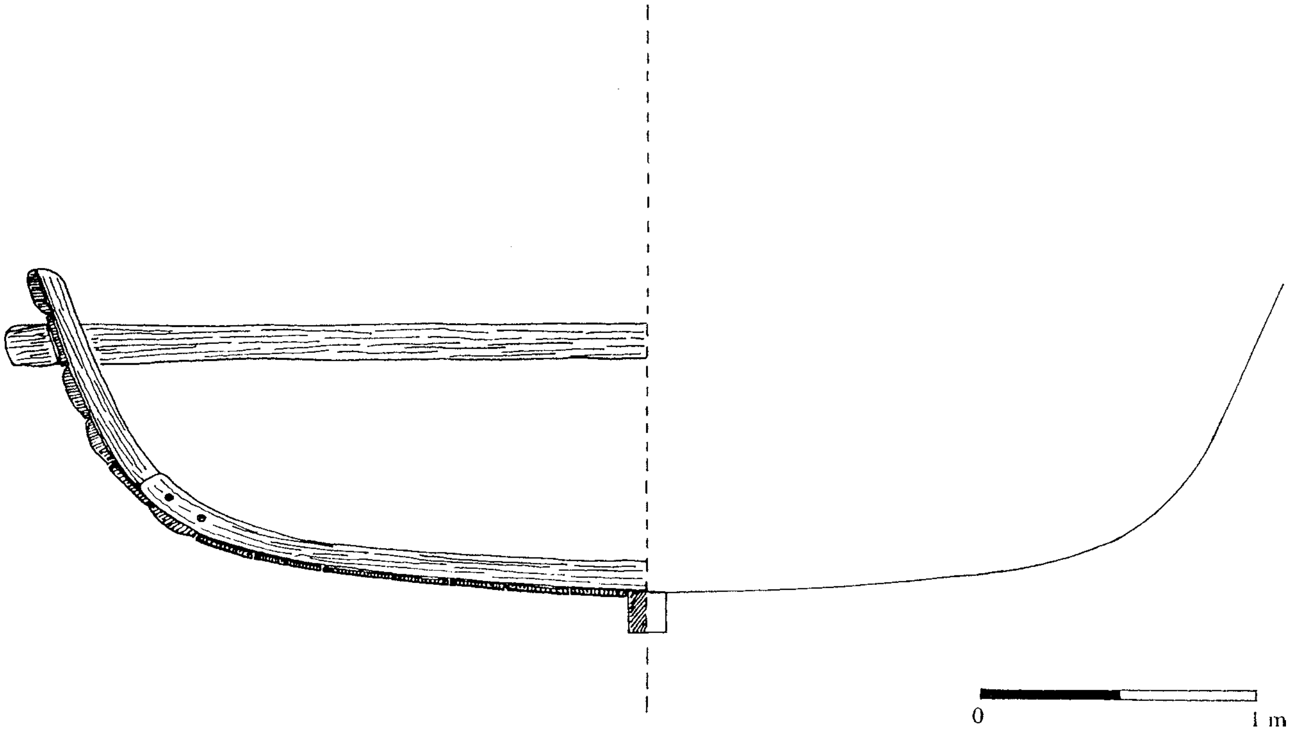

Fig. 18.2. Reconstruction of the master frame with a beam which protrudes beyond the planking on both sides.

the two traditions of inland shipbuilding attested in the region before the 12th century are the log boat and the joined-monoxylous traditions. In other respects, the carvel strakes, the caulking driven in from the outside of the strakes, the direction of the joint between the strakes and the frames (treenails driven in the frames from the outside of the planking) ..., can permit us to conclude that the hull structure has been built according to the "skeleton first" method. It is not the subject of this paper to discuss the historical consequences of this archaeological evidence of a "skeleton first" construction in the Atlantic context of the early medieval period. But, in relation to the problem of the development of the medieval "carvel" construction, the *Port Berteau II* wreck could permit, by its dating, a new reading of this important historical question.

The architectural reconstruction of the hull, founded on the unfolded/developed plan of the starboard planking on the one hand, and on 32 cross sections of the hull (Fig. 18.3) on the other hand, has been realized with the collaboration of a naval architect, Marc Ginisty. It is necessary to specify that the archaeological remains constitute about 15% of the totality of the reconstructed hull, a slight percentage comparable, however, with those of the *Yassi Ada 1* (Bass, van Doorninck *et al.*, 1982) or the Serçe Liman (Steffy, 1982: 198) wrecks. But, in the after part of the *Port Berteau II* wreck, the archaeological remains constitute about 80% of the stern, a percentage which reduces in great part the possibilities of interpretation.

The main characteristics of the reconstruction are (Fig. 18.4):

- axial structure built on a keel;[1]
- 14.30 m in length overall, 10.30 m in length of keel, 4.80 m in breath and 1.20 m in depth in hold;
- weight of the hull: 5.7 tons in light condition and 6.8 tons ready to sail without ballast;
- maximum burden: about 10 tons.

The operating process: from the "customer" to the shipwright

Through the characteristics of the wreck, three stages of the operating process of the shipyard can be reconstructed. The first, which corresponds to the functional choice of the "customer", is revealed by four principal elements. The relation between the length of the hold and the length overall gives a coefficient of 0.591. Compared with other coefficients of early medieval wrecks (Mc Grail, 1987: 203), the coefficient of the *Port Berteau II* wreck is one of the highest and indicates that cargo capacity was probably the first architectural factor selected. The shape of the master-frame – flat floor-timber, chine with a great arc, vertical sides – is favourable to great cargo capacity

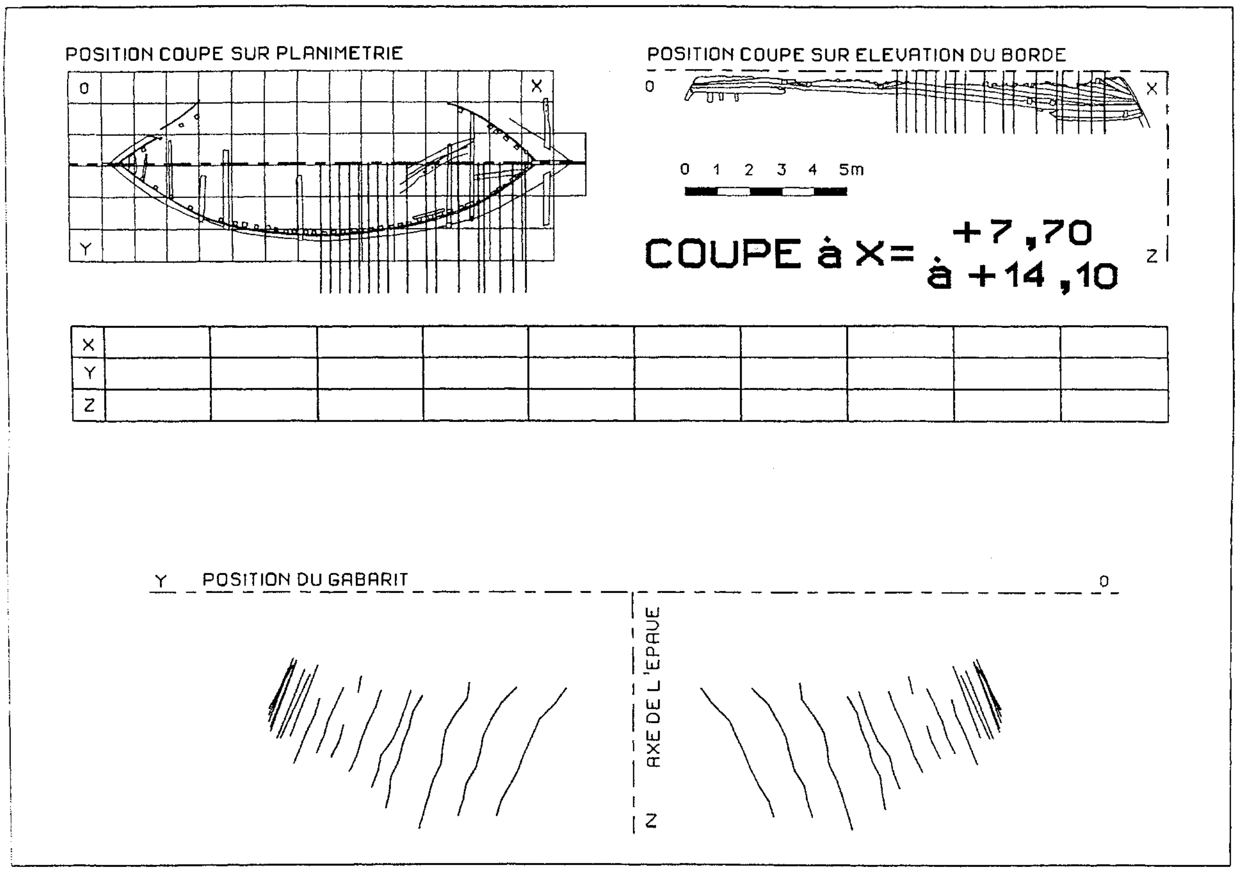
POSITION COUPE SUR PLANIMETRIE
O
X
Y
POSITION COUPE SUR ELEVATION DU BORDE
O
X
Z
0 1 2 3 4 5m
COUPE à X= +7,70 à +14,10
X
Y
Z
Y POSITION DU GABARIT
O
AXE DE L 'EPAVE
Z

Fig. 18.3. Cross sections of the after part of the wreck.

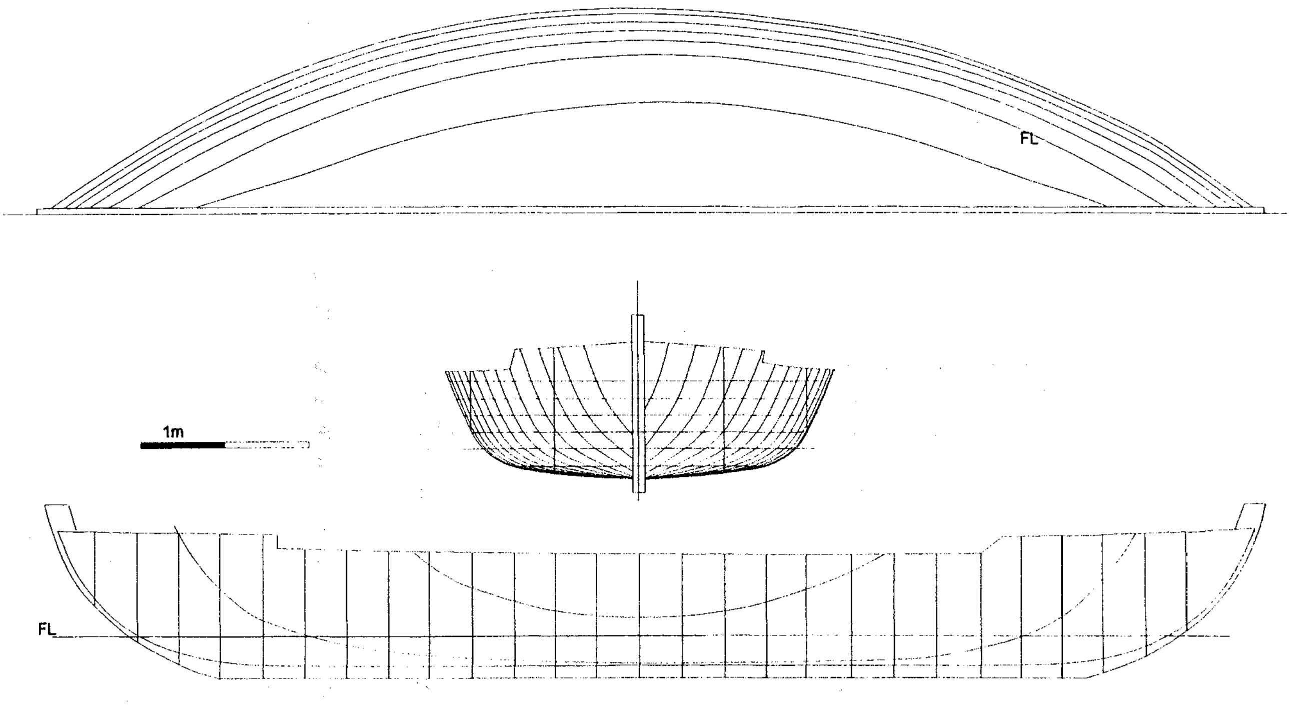

Fig. 18.4. Reconstruction of the lines.

and, also, to small draught and good beaching, two nautical characteristics of inland and coastal navigation. The low freeboard – 90 cm in light condition and 40 cm in load – is the sign of navigation in maritime protected waters. The position of a beam in the area of the hold, a little before the middle of the length overall, is evidence for propulsion by sail.

From the point of view of the "customer", the architectural project of the *Port Berteau II* ship can be abstracted in those economic and technical terms: a sailing merchant ship with a maximum burden of 10 tons, which must be able to navigate along the coast and on inland waters, and to beach with facility on the shore and along the banks of a river.

The second stage of the operating process corresponds to the reply of the shipwright to the conditions expressed by the "customer". Two levels of answer can be determined. Firstly, the shipwright, with his knowledge and experience, is able to translate in precise architectural terms the request of the "customer", that is to say: definition of the dimensions and proportions (b/LOA: 1/2.9; d/b: 1/4; d/LOA: 1/11.9), design of the hull, shape of the master-frame, type of structure, method of construction. Secondly, he can define the different sorts of supplies (wood and iron in particular), which are necessary to the materialization of his architectural project.

For this crucial aspect of the operating process, the dendrochronological study has given some precise data. Oak (*Quercus sp.*) was the only species selected by the shipwright. Most of the trees, felled during the winter in a period of no growth, come from the same open area situated at a low altitude. In general, the trees are young, with a diameter of 10 to 30 cm.

The nails give other interesting data. They can be classified into five principal groups according to the shape of their head: nails with triangular, square, rectangular, round and "en bouton" head. Some groups have particular functions. The nails with triangular head (Fig. 18.5), for example, have been used to join the butts of the wales in the bow and the stern while the nails with rectangular head have been used to join the planks of the fore deck to the beams.

From the point of view of the shipwright, the necessity to find oaks, nails, but also oakum and pitch for the caulking of the seams of the planking, involved the existence of an organization to collect the various raw materials and to transport them to the shipyard. One question is concerned with the nautical specificity of this organization. Indeed, an ambiguity exists for some supplies. For example, the nails with triangular head are not exclusively used in shipbuilding, but also in housebuilding.

If we examine now the point of view of the "customer", the supplies imply an investment, the nature of which will differ depending on whether the "customer" is, or is not, the owner of the forest, the field or the smithy.

The third stage of the operating process corresponds to the building of the *Port Berteau II* ship. The first problem is the situation of the shipyard. The principal evidence for a regional shipyard is given by the nautical features of the ship. The low freeboard, the small draught, and the open hold are characteristics only suitable for coastal navigation in protected waters. In this perspective, the shore protected from the open sea by the islands of Ré and Oléron and limited by the river Sèvre Niortaise to the north and the river Seudre to the south, seems one of the hypothesis for the location of the shipyard. The other hypothesis could be the estuary or the banks of one of the three rivers of this area. The dendromorphological characteristics of the oaks felled for the building of the hull and the nature of the vegetable oakum used for the caulking constitute two supplementary clues which suggest that the shipyard was near the sea, an estuary or a river.

The second problem is the identification of the technical operations associated with the building of the "skeleton first" *Port Berteau II* ship. The transformation of the oaks into planking and ship's timbers is realized according to two methods. All the longitudinal pieces (carvel strakes and deck planking) were cleaved and fashioned with axe

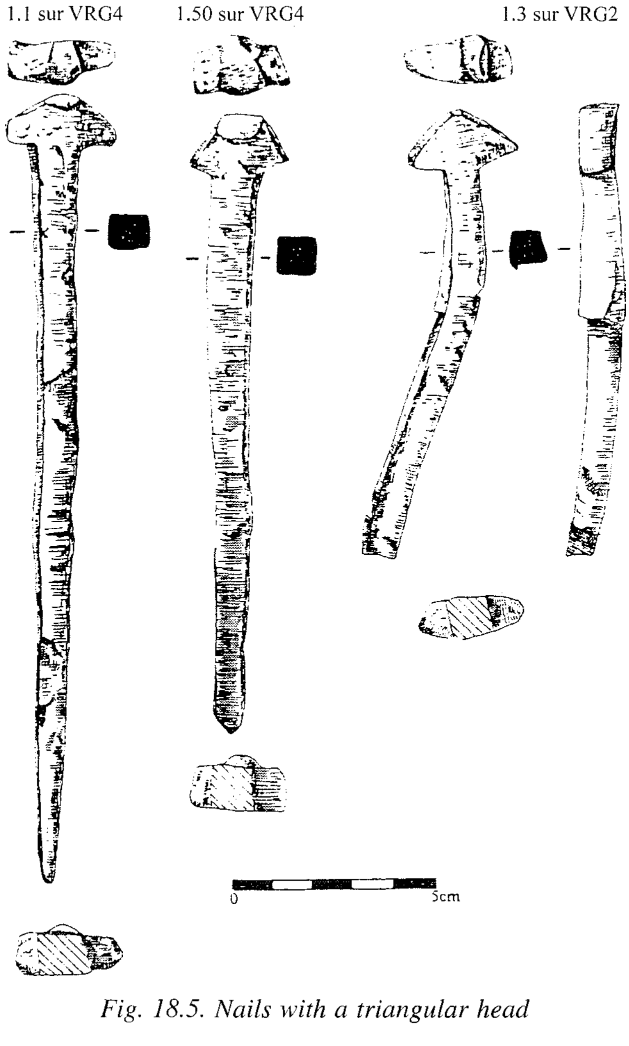

Fig. 18.5. Nails with a triangular head

and adze. The other elements of the hull (stem, stern, beams, frames) were shaped by reduction, with axe and adze, of a trunk, a half-trunk or a big branch. The joint between the frames and the carvel strakes involves two operations: drilling a hole in the planking and the frames and then, driving in treenails, from the outside of the planking. For the butts of the strakes in the stem and the stern, the nails are directly driven into the wood. The same operation is used when nailing the deck planks to the beams. Another important operation is the caulking of the seams between the carvel strakes with vegetable oakum mixed with pitch and driven in from the outside of the planking.

To cleave, to fashion, to shape by reduction, to drill, to drive in treenails, to nail, to caulk...: these operations must not be necessarily associated with different workmen. Moreover, a nautical specialization seems not always a necessity. For example, a carpenter of houses could have joined strakes to frames. Nevertheless, other operations as, for example, the shaping of the strakes or the caulking of the seams, involve the participation of specialized workmen. Lastly, an overseer of the shipyard seems an absolute necessity to manage, to arrange and to control every stage of the building.

The third problem is the evaluation of the technical level of the shipyard. Using a theoretical unit of measure, according to the J. R. Steffy's method used for the study of the Serçe Liman wreck (Steffy, 1991), the principal dimensions of the hull form a coherent dimensional system, which can be interpreted as a sign of a strict geometrical definition of the architectural project (Fig. 18.6). Our theoretical unit of measure corresponds to 60 cm, that is to say the distance between the two fore crossbeams TRV3 and TRV4. Using this unit, the length overall, for example, is equal to 24 units, the breath is equal to 8 units, the depth in hold is equal to 2 units, the distance between the mast-beam (TRV 5) and the aft beam (TRV 6) is equal to 4 units ... Another illustration of the technical level is given by the plan of the planking (Fig. 18.7). In the aft part of the hull, for example, the planking shows a geometrical organization indicating technical capabilities. This organization rests on two particular strakes (VRG2 and VRG7), which correspond to the greatest breath and the middle of the chine.[2] In relation with this position, the two strakes can be considered as strakes of reference or strakes of "architectural regulating".

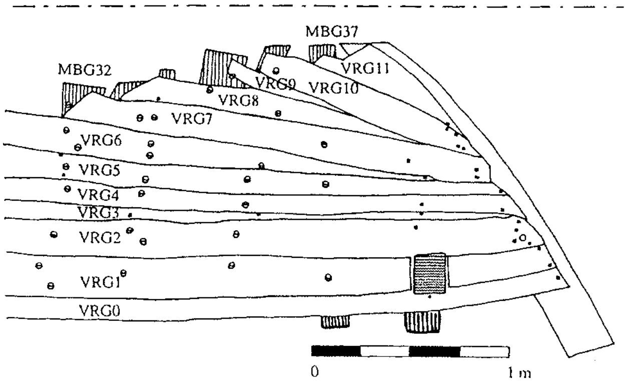

Fig. 18.7. Unfolded, developed, plan of the aft part of the starboard planking.

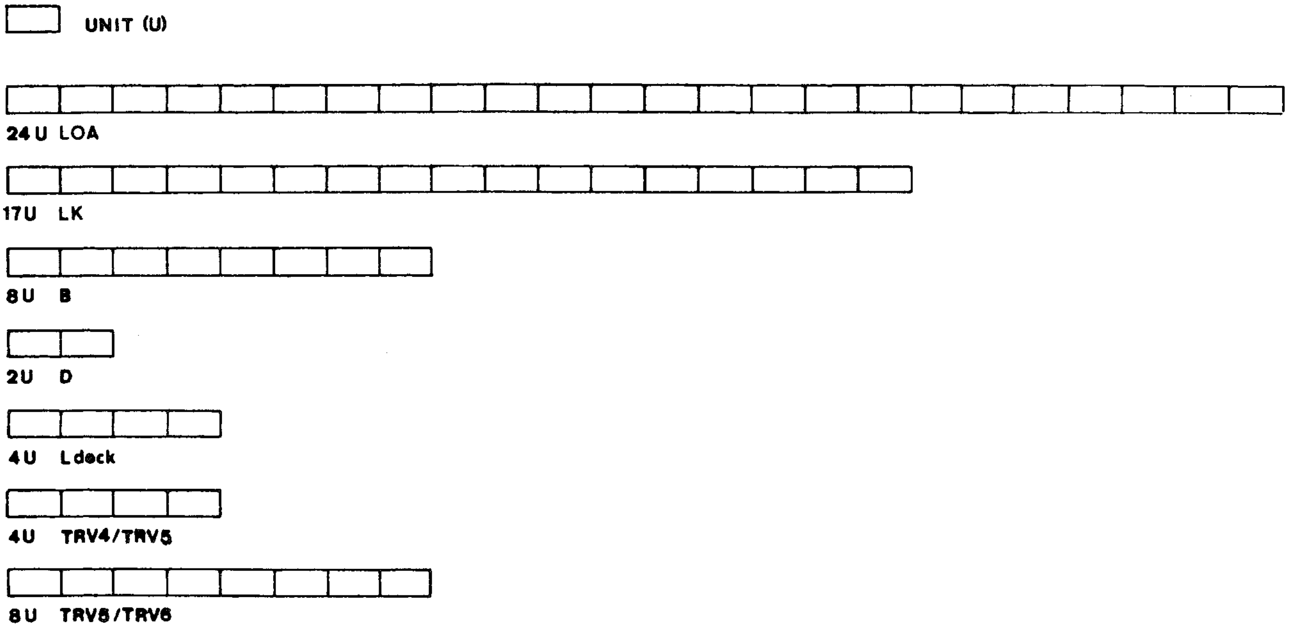

Fig. 18.6. The major dimensions of the hull in relation to a theorical unit of measure (60 cm).

These two examples of technical capabilities seem to be understood only in relation to experience, past and, perhaps, "tradition",[3] in shipbuilding. In other words, the *Port Berteau II* ship does not look as an architectural exception. But the great question, without answer, is the historical and chronological position of the ships in this past of shipbuilding.

The functional context

The last aspect to study is the historical interpretation of the *Port Berteau II* shipyard. We must recall that during the Merovingian period, an important part of the Santons territory was covered by forest (the *Silva Sanctonica*) in which oak was the principal species (Jouannet, 1992; Luc, 1981). The culture of corn and vine expanded during the 6th and the 7th centuries. Along the coast, there was salt production. The regional economy had mainly a rural character. The only important town was Saintes, situated in the middle of the region, and connected to the sea by the River Charente. In this rural context, where Saintes could be the only "maritime town upstream on a river", according to Jan Bill's typology (Bill, 1999: 254), water transport was associated with a "closed" economy, without any maritime harbour orientated towards foreign trade. It was during the second part of the 12th century and the 13th century that two harbour towns grew in relation to the international wine trade with England and Flanders: La Rochelle along the coast and Saint-Savinien on the Charente. From the socio-economic point of view, the church, and in particular the bishop of Saintes, had an essential position since the Franks conquest. In spite of the power of the church, the old Gallo-Roman aristocracy still had great domains with labour composed, in part, of slaves.

In these conditions, it appears that the building of the *Port Berteau II* ship and its regular use as a freighter on the Charente and along the coast could be associated with one of the two regional powers and possible "customers" and owners of the ship: the church or some important land owners. In a pre-merchant economy, the agricultural *surplus* of the ecclesiastical or lay domains, and salt could have been the principal freight of the *Port Berteau II* ship.

Conclusions

In conclusion, we must recall that the *Port Berteau II* ship represents, before the development of the international maritime economy of the 12th–13th centuries, one architectural tradition of the regional water transport system. The two others, specifically associated with the inland navigation, are the log boat and the joint-monoxylous traditions, which, at another technological level and socio-economic scale, illustrate the importance of water transport in the early medieval context of the regional rural economy.

Notes

[1] The preliminary reconstruction (1997), with the aid of different models, have showed that one of the best hypothesis of restitution could be associated with a flat-bottomed hull (Rieth, 2000b: 227). After three years of research, this preliminary hypothesis has been abandoned. The only possibility of reconstruction is a hull built on a keel with a flat floor-timber.

[2] The strake VRG2 has the same function as a high ribband (extreme breath line) and the strake VRG7 has the same function as a low ribband (rising line of the floor).

[3] We use the term "tradition" in relation to the fact that the hull of the *Port Berteau II* ship must have been designed with reference to other ships more or less similar.

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19. Nails for Shipbuilding (13th–20th centuries)

Furio Ciciliot

Introduction

The purpose of this research project is to obtain more in-depth information about the small iron components (especially nails from the Genoese area) used in shipbuilding, starting from the oldest period for which systematic evidence has remained (13th and 14th centuries). The production of larger iron items, such as anchors and pieces of artillery, have not been considered up to this point, but certainly merit separate discussion.

The sources can be grouped into three different areas: archaeology, documents and ethnography. Archaeological sources included excavations in addition to an extensive and rare collection of nails and other small iron components preserved in the Civic Museum of Masone, near Genoa-Italy.

The comparison between the Masone nails and those described in notary documents was quite useful. Years of research along with an extensive analysis of tens of thousands of notary acts were required to gather the few dozen technical documents used here (principally covering a period of slightly more than one century [circa 1445–1566]).[1]

Production sites and artisans

This report focuses on the finished product: the products that artisans worked on in private shops, converting a semi-finished product of small bars obtained from iron-works and smiths' shops. The documents that describe the artisans' activities are insufficient to outline all characteristics of their work or, at least, their professional careers, beyond the apprenticeship contracts that are similar to those of other professions. However, the documents found can indicate the production locations. They are located in the Savona hinterland, also considering that the documents examined come mainly from the western coastline of the Italian Riviera (from Genoa to Savona), the area with the most important private shipyards.

Metrology of the finished product and its uses

The initial obstacle to overcome involved the metrology of the products, which is always the case in old technical documents. An emblematic example of such a problem involves the typical measurement for the quantity of nails: the *ballone*. The ballone does not have a unique dimension: it may be a fixed number of nails (*aguti,* in Genoese language. From 2.000 to 4.000 every *ballone*), or may also indicate an equivalent weight in *rubbi* (from 3 to 4.5, each equal to 7.91 Kg, therefore about 24 to 36 Kg) or in *libbre* (from 45 to 60, each 317 gr, and thus approximately 14 to 19 Kg). Thus, the measurement in *balloni* is uncertain: even those who wrote the documents almost always indicate how many thousands of pieces constitute the ballone or its equivalent weight.

In the documents, the definition of a nail involves two different types of measurements: one in terms of length and the other in weight. Sometimes they are both provided: this is the most valuable information because it provides us with the length and the thickness of each piece that, in the future, is easy to compare with archaeological finds. The length is measured in *dita*, equal to 1/12 of the *palmo genovese* (24.8 cm / 12 = approx. 2.06 cm). The weight of the nails is indicated sometimes in *rubbi* or in *libbre* per thousand.

Documents about nails prior to the 14th century are rather sporadic. The following is a list of some unpublished documents that include information about nails used for shipbuilding:

*Genoa, 1st May 1222 (*Ferretto, 1906)*:*

- a hundred *acuti torarii* for 14 *denari*;
- a hundred *acuti somesarii* for 4 *soldi*;
- a hundred *acuti pugnarecii* for 2 *soldi;*
- a hundred *acuti stoparoriis* for 8 *denari*;
- pins for 8 *denari* each.

Genoa, 9 September 1267:[2]
delivery of 140 *rubbi* of *acuti* at 170 each *rubbo*, i.e. each *acutus* weighed 46.5 gr;

> *Genoa, 26 June 1274:*[3]
> *Arduinus ferrarius* of Savona promises to deliver in Savona *accuti boni et sani* (nails good) of iron necessary for a ship at six soldi for each rubbo.

Types and products of the late and post-medieval centuries

Now we will examine the nails from the 14th century, followed by those from the 15th and 16th centuries and finally the last production of Masone in the 19th and 20th centuries.

In general, the nails can be divided into some different basic types: various types of nails, similar to the modern version (*aguti*), where one end terminates in a point to be inserted into the material that receives it and the other flattened to provide a surface for hammering. Some nails were used to retain the tow (*stopparoli*); *claves* that would seem to be nails supplied with an additional crown (*burdus*) that is rather wide: in fact, in one document it is specified as *clavis sive acutus burdi*. We can probably say that the term *clavis*, at least in this treatise, does not refer to keys in the modern sense of the word; pins, i.e. nails with a round cross-section without a point or a head.

The following page is a list of dimensions and specifications of various products. However, we can not clearly identify all those used for ships. If those *a coperta* may be used for the upper works of the vessel's deck, and those *de plano* for the bottom of the hold, we don't know how the *barcha vetera* nails were used, a possible sign of a technological change around the beginning of the 16th century, when a distinction was obviously made between those for old and new vessels. As already mentioned, we are quite familiar with the use of the *stopparoli* and we can imagine that those *a queratis* fasten the boards of the planking to the framework. The dimensions of the iron components also vary quite significantly, but we hope they will be adequate to allow them to be identified through archaeological finds.

Small iron pieces for galleys (14th century)

A Genoese galley construction book from 1354[4] mentions the small iron components needed to build galleys. In general, these are nails (*agui*) followed by a specification about the type of use. The following shows the types identified for which, unfortunately, the size is only rarely indicated:

> *aguij semesaij, aguij toraij, aguij de dia III (=* cm *6.18), javete, aguij pugnareci, agogia pro timone, aguij da tacho, aguij da bancho, aguij da bancheta, stopaijro.*

Unfortunately, as we can see, the information at our disposal is quite limited, since we do not know the technical meaning relative to the use of all the different types and because we lack the dimensions of the pieces. Similar conclusions can be reached from another galley construction book from 1359 (Nicolini, in press)[5] in which the following small iron components are mentioned to construct galleys:

> *stoparolij, agui* (their dimensions are *dita* 2.5; 3; 3.5; 4 = cm 5.15; 6.18; 7.21; 8.24), *agui bordi sive toray da dita 4* (=cm 8.24).

The only conclusion that we feel can be made is that, probably, the small iron *torai* are those in which another edge was added to the head of the nail. The type of small iron pieces with a point is however rather well defined: the term *agutus* indicates the generic nail. One particular type of this nail is called the *stopparolo*, while if it has an additional edge it becomes the *toraus*.

Small iron components from the 15–16th centuries

Some documents from the 15–16th centuries relating to the construction of galleys appear to be much more complete. They describe the small iron components with their specific dimensions. The first of these is an unpublished estimate, from 147[1] to build galleys by Genoese workers. An artisan guild supplied the small nails (arte de *pexaroli*) including the metal materials as well as the tow, pitch and other minor materials:

> *Magisterio de larte de pexaroli: Stopa grossa rubi IIII, lire II soldi V; pexa per respecto rubi IIII, lire I soldi XVI; stropi donzene X, lire I soldi X; chiodi da bancho a numero 500 a soldi 3 1/2 per centenario, soldi XVII denari VI; chiodi da tacho a numero 250, lire I; chiodi da dido (= cm 2.06) a numero 750, lire I; chiodi de dita III 1/2* (= cm 6.18) *a numero 750, lire I soldi VIIII denari VI; stoparoli MDCCC, lire II soldi XI.*

As we can see, the standard supply of nails on a galley, and thus not really for its construction, but for use on board and for any repairs, includes *bancho* nails, *tacho* nails, *dido* nails (with a length of about 2.06 cm) and 3.5 *dita* nails (about 7.21 cm) in addition to a large number of *stopparoli*. The small *dido* nails could have been used only on board and not for the hull of the vessel.

The most precise definition of the nails required to build a Genoese galley in the middle of the 16th century is found in a document from Florence dated 1552 (see Borghesi, 1970; Gatti, 1999). This document also provides us with information about the indispensable types of nails, giving us the reasons why they were used. The fundamental parts of the various types are provided here:

> *perni da giugnere et da piano, lunghi dita 9* (= cm 18.54); *perni da coiro di dita 11* (= cm 22.66)*; perni da cinte di dita 13* (= cm 26.78); *perni da carena, per la corsia, per baccalari, per le corde della coperta, da*

> *dita 17* (= cm 35.02), *la maggior parte, et parte di dita 18* (= cm 37.08), *et parte di dita 20* (= cm 41.2) *et parte di dita 27* (= cm 55.62), *secondo le grossezze delli legniami; aguti da chiavare la coperta di dita 9* (= cm 18.54); *aguti di 1500 a ballone; aguti di 2000 a ballone.*

The same document specifies the basic differences between the *perni* (= pins, *di chiovagione tonda*) and the *aguti* (= nails, *di chiovagione quadra*). The various dimensions of the nails are also indicated according to the wood (*quando è grossa schiappa et quando è troppo sottile non tiene* = when the nails are large they break the wood). The note does not indicate the dimension of the stopparoli or the dimensions in weight of the iron pieces.

A very important document concerning the nails used in naval applications is the famous Venetian manual known as the *Fabrica di galere*. The following is the information provided in an unpublished copy of the manual (probably dating back to the end of the 16th century) conserved in Milan (*agudo, agudi = acutus, agutus*).[7]

> Agudi de libra si chiamano quelli che pesano da lib 10 in su il centenaro; agudi di septena si chiamano quelli che pesano da lib 8 fin 10 il centenaro; agudi di cinquena sono quelli che pesano da lib 6 fin in 7 il centenaro; agudi di sesena debono pesare lib 5 il centenaro; agudi di quaerno e mezzo debono pesar lib 4 e mezza il centenaro; agudi de cento agudi di quaerno debono pesar lib 3 1/2 il centenaro; agudi da terno debono pesar lib 2 1/2 il centenaro; agudi da 2 debono pesar lib 2 il centenaro; agudi da 1/2 debono pesar lib 14 il migliaro; stoparoli d'ogni sorte voleno esser di ferro dolce et voleno haver le teste sutile et crespe perché sono assai megliori per tegnir le stope.

In the Venice area (but probably in other places as well), each type of nail usually got its name from its weight: thus, the proportions of the pieces are standardised, with the only exception being the *stopparoli* that must have a special head to hold the tow more effectively. This situation just described refers to Venice, but it is also likely to apply (with other terminology) to Genoa.

Nails mentioned in notary acts from the 15–16th centuries

The most complete documents found are notary acts. Although rather fragmentary, they provide us with information that up to now was not found in other types of documents. For example, the length and the weight of the various iron components, in addition to the places and the quantities produced. The following is a set of notary acts regarding the construction of nails that were likely or definitely used for ships.

agutus[8]				
1520:	libbre 20 per miliario (=1.000)	each	g	6.34
agutus[9]				
1507:	di 3 dita = cm 6.20, libbre 11 per 1.000	each	g	3.49
1507:	di 2.5 dita = cm 5.15, libbre 6 per 1.000	each	g	1.90
1508:	di 3 dita = cm 6.20, libbre 10 per 1.000	each	g	3.17
1529:	libbre 15 per 1.000	each	g	4.76
1530:	libbre 9 per 1.000	each	g	2.85
agutus a bancho[10]				
1507:	rubbi 4.5 per 4.000	each	g	8.90
agutus a barcha veterus[11]				
1528:	rubbi 3 per 2.000	each	g	11.87
agutus a coperta[12]				
1502:	ogni 12 per libbra	each	g	26.40
agutus de asparegeto[13]				
1507:	rubbi 4.5 per 2.000	each	g	17.80
agutus de plano[14]				
1502:	once 4 each	each	g	105.67
agutus burdi[15]				
1476:	di 4 dita	each	cm	8.27
clavaxionis a bancho[16]				
1508:	rubbi 4 e libbre 10 per 4.000	each	g	8.70
clavis[17]				
1554:	di 12 dita	each	cm	24.80
1554:	di 10 dita	each	cm	20.67
clavis[18]				
1521:	digiti 4 de libris 18 per 1.000	each	cm	8.27
			g	5.71
1521:	digiti 3.5 de libris 10 per 1.000	each	cm	7.23
			g	3.17
1521:	digiti 3 de libris 6 per 1.000	each	cm	6.20
			g	1.90
clavis a coperta parvus[19]				
1521:	libbre 36 per 1.000	each	g	11.41
clavis sive acutus burdi[20]				
1490:	lenght dita 3.5 = cm 7.23, libbre 24 per 1.000	each	g	7.61
1490:	lenght dita 4.0 = cm 8.27, libbre 36 per 1.000	each	g	11.41
clavis de barcha vegia[21]				
1539:	libbre 60 per 2.000	each	g	9.51
pernus a riondo[22]				
1502:	each libbre 1 once 9	each	g	554.75
pernus a queratis[23]				
1502:	each libbra 1 and once 1	each	g	343.42
stopparoli[24]				
1501:	rubbi 4 per 3.000	each	g	10.55
1528:	libbre 20 per 1.000	each	g	6.34
1545:	libbre 48 per 4.000	each	g	3.80
1562:	libbre 45 per 3.000	each	g	4.76

Nails from archaeological excavations ashore and from the Museo Civico di Masone

An archaeological check of nails allowed us to measure those conserved in the Museo Civico di Masone, comparing them with the finds from several shore-based archaeological excavations in the surrounding areas. Based on the following fragmentary tables, it was not possible to theorize a historical evolution of the products. The nails of the 13th century, at least those not specialized, are very similar to those made by hand in the middle of the 20th century.

Date Century	Conserv. Place	lenght mm	head mm	Width Corpo	Weight G
XX	Masone	50	10	4	6
XX	Masone	65	12	5	8
XX	Masone	70	11.5	4	8
XX	Masone	80	10	5	9
XX	Masone	80	15	5	16
XX	Masone	90	12	5	10
XX	Masone	100	18	5	21
XX	Masone	120	17	7	32
XX	Masone	160	20	8	62
XX	Masone	200	24	10	103
XX	Masone	210	26	11	121
XX	Masone	280	35	12	202

Date Century	Conservation Place	Excavation place	Length mm	head mm	Width of nail mm	Thickness of head mm	Weight g
XII	Savona	Andora Castello	52	20	5	3	13
XII half	Savona	Priamàr-Loggia	70	20	7	3	20
XIII beginning	Savona	Priamàr-Loggia	80	20	8	3	21
XIII beginning	Savona	Priamàr-Loggia	90	14	5	4	19
XIII half	Savona	Priamàr-Loggia	45	20	5	4	13
XIII half	Savona	Priamàr-Loggia	50	15	6	2	10
XIII half	Savona	Priamàr-Loggia	55	25	8	4	25
XIII half	Savona	Priamàr-Loggia	55	10	4	3	8
XIII half	Savona	Priamàr-Loggia	75	15	4	3	11
XIII half	Savona	Priamàr-Loggia	80	15	6	2	11
XIII half	Savona	Priamàr-Loggia	100	15	6	2	14
XIII half	Savona	Priamàr-Loggia	105	22	10	3	48
XIII half	Savona	San Domenico	85	15	5	3	11
XV beginning	Savona	San Domenico	75	20	8	3	29
XV beginning	Savona	San Domenico	85	17.5	6.5	3	25
XV beginning	Savona	San Domenico	85	19	8.5	3	25
XV beginning	Savona	San Domenico	90	18	8.5	3	26
XV beginning	Savona	San Domenico	110	20	8.5	3	39
XV beginning	Savona	San Domenico	130	21.5	10	3	61
XV beginning	Savona	Spotorno Castello	80	11	4	3	9
XV beginning	Savona	Spotorno Castello	170	25	10	3	76
XV half	Savona	Spotorno Castello	55	10	3	3	4
XV half	Savona	Spotorno Castello	70	15	4	3	8
XV half	Savona	Spotorno Castello	90	15	3	3	10
XVI	Savona	Andora	40	15	4	4	10
XVI	Savona	Andora	45	20	5	4	10
XVI	Savona	Andora	45	14	4	4	8
XVI	Savona	Andora	60	14	4	2	8
XVI	Savona	Andora	70	15	5	2	11
XVI	Savona	Andora	72	14	7	2	11
XVI	Savona	Andora	80	12	6	3	14
XVI	Savona	Andora	85	10	4	2	8
XVI	Savona	Andora	90	17	6	4	26
XVI half	Savona	Andora Castello	30	15	3	2	6
XVI half	Savona	Andora Castello	40	10	3	2	3
XVI half	Savona	Andora Castello	40	9	3	2	4
XVI half	Savona	Andora Castello	40	18	5	3	13
XVI half	Savona	Andora Castello	47	12	2	2	4
XVI half	Savona	Andora Castello	60	18	7	3	19
XVI half	Savona	Andora Castello	68	15	5	3	11
XVI half	Savona	Andora Castello	90	15	5	3	16
XVI half	Savona	San Domenico	55	12.5	5.5	3	6
XVI half	Savona	San Domenico	60	15	5.5	3	6
XVI half	Savona	San Domenico	65	13.5	5.5	3	5
XVI half	Savona	San Domenico	70	15	5.5	3	6
XVI half	Savona	San Domenico	95	17	11	3	43
XVI half	Savona	Spotorno Castello	115	20	5	3	30
XVI half	Savona	Spotorno Castello	115	22	6	3	55
XVI half	Savona	Spotorno Castello	150	15	5	3	36

As we can see from the tables, the information already noted in the Venetian manual has been confirmed: a large number of the proportions among the measurements of nails tend to repeat. The discriminating factor is probably their weight.

Conclusions

This brief research project will require archaeological comparisons that, up to today, have been rather limited: in fact, no other similar research in the Genoese field has been conducted. Comparisons may emerge from the most diverse fields: the first that come to mind are those from underwater archaeology, despite the problems in preserving iron under water. But other confirmations may come from shore-based archaeology or even from a study of ancient buildings.

The role of raw materials in naval constructions merits separate discussion. Up to now, the research in the field of naval design has been considered more important than the studies of the materials used. However, we believe that such factors are just as important and that they should be researched at the same time. A precise design is needed to build a good vessel but also excellent raw materials.

We hope that these brief notes will provide the *stimulus* for additional research. In addition, the information provided in the previous tables may lead to an initial classification of the small Genoese iron components used for ships to make comparisons with those from other traditional construction methods.

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Notes

[1] In the references, when the documents are conserved in *Archivio di Stato di Savona* we do not write the archive: the name is that of the notary (for example: *S.Capello*) with the date of the notarial act.

[2] Archivio di Stato di Genova (ASG), *Notai antichi, Guglielmo de Sancto Georgio*, photo box 90.

[3] ASG, *Notai antichi, Leonardo Negrino*, photo box 146.

[4] ASG, *Antico comune*, manuscript 4/12/1354.

[5] ASG, *Antico comune*, 702.

[6] Archivio di Stato di Milano, *Sforzesco*, 444, manuscript 14/9/1471.

[7] Milano, Biblioteca ambrosiana.

[8] *S.Capello*, 26/6/1520.

[9] *S.Capello*, 19/10/1507; *S.Capello*, 6/4/1508; *V.Capello*, 30/6/1529; *V.Capello*, 2/4/1530.

[10] *S.Capello*, 19/10/1507.

[11] *V.Capello*, 25/11/1528.

[12] *B.Bertolotto*, 29/1/1502.

[13] *S.Capello*, 19/10/1507.

[14] *B.Bertolotto*, 29/1/1502.

[15] *G.Faia*, 22/5/1476.

[16] *S.Capello*, 6/4/1508.

[17] *A.Ricci*, 23/3/1554.

[18] *S.Capello*, 29/1/1521.

[19] *S.Capello*,29/1/1521.

[20] *N.Priano*, 25/1/1492.

[21] *A.Ricci*, 12/6/1539.

[22] *B.Bertolotto*, 29/1/1502.

[23] *B.Bertolotto*, 29/1/1502.

[24] *G.Giordano*, 26/2/1501; *V.Capello*, 25/11/1528; *A.Ricci*, 6/5/1545; *A.Ricci*, 26/3/1562.

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20. How Were Vessels Designed before the Late-Medieval Period?

Seán McGrail

Introduction

A definitive answer to the question, "How were early boats designed?" still eludes us: work is still in progress. The aim of this present paper is to summarise the medieval and earlier European evidence as it is known today, concentrating on how the size and the shape of hulls were determined. It is not intended to take into account constraints on design such as variable characteristics and dimensions of available timber, nor to consider how designs might be modified to allow for variations from the norm. Comparative evidence from recent ethnographic fieldwork in South Asia will be considered when relevant.

A simple answer to the question posed is that early boats were not designed, if by "design" one means that the desired form and structure of a boat are first encapsulated in a set of scale drawings or in a scale model. That definition has to be broadened to include methods other than those with which 21st century Europeans are familiar. Steffy (1995b: 417) has suggested a definition: 'the ways in which shipwrights controlled hull construction'. An alternative could be: 'any process used to ensure that a hull is built to the size, shape and structure required'. Methods of designing a vessel can thus lie within a spectrum which ranges from a 'low tech' end, where the design is entirely "in the mind" (the sole use of a mental template), to a 'high tech' end where 21st century formal design methods are used.

A fair amount is known about the design system used in late-medieval Venice, and subsequently in the Mediterranean and in Atlantic Europe, since late-medieval and post-medieval documents have survived which describe and illustrate these techniques (Barker, 1988; 1991; Bellabarba, 1993; 1996; Grenier *et al.*, 1994; Steffy, 1994; Rieth, 1996; Loevan, 2000). This paper, however, deals with earlier times whence little, if any, documentary or illustrative evidence of design techniques has survived. The first question to be asked, therefore, is whether there is any evidence for early artifacts which could have been used as aids to design. Such conjectural artifacts would be forerunners of the tablet and the lofting floor of the Venice /Atlantic frame-first design system (Bellabarba, 1993); and the boat ell, the boatbuilder's level, (Fig. 20.1) and moulds (patterns or templates) which Christensen (1972) has shown were used in recent centuries as aids to building plank-first boats in northern Europe. A literature survey indicates that no such artifact has been published: all known aids to design appear to be post-medieval or, at best, late-medieval. It may be, then, that we are dealing with a problem for which there are no artifact pointing towards a solution.

Ethnographic evidence has proved rewarding when investigating the problem of early navigation without instruments (McGrail, 1983), and we can certainly learn about aspects of design from today's traditional boatbuilders: see, for example, the Appendix to this paper dealing with simple rules of thumb for Indian and Inuit hide boats, and for Chinese junks. However, we also have the surviving remains of early hull structures, the end product of an unknown design system: clues to that system can lie in the hull itself and may be revealed by such investigations as:

- the identification of boatbuilder's marks;
- the establishment of a vessel's building sequence, the hull's internal stratigraphy, as it were;
- the recognition of a unit of linear measure – not necessarily known legal units, but also units based on the human body, and other units of unknown name;
- the investigation of a possible modular length (for example the maximum breadth or the keel length) such that other hull dimensions can be expressed as a proportion of it;
- the estimation of the radius of curves in a hull: for example, those of framing timbers in a frame-first vessel;
- the specification of angles in the hull in terms of their tangent (offsets from two orthogonal axes: for example, 2 units vertically for every 7 units horizontally).

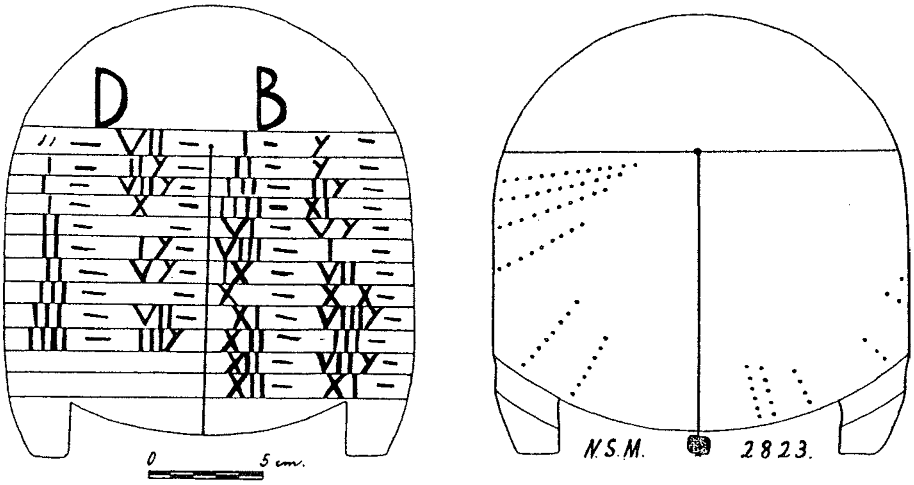

Fig. 20.1. Two sides of a recent Norwegian boatbuilder's level for a 12-strake boat, with angles and breaths of strakes marked in code (after Christensen, 1972, fig. 2).

The sum total of such information probably cannot add up to a comprehensive design system, but it does let us appreciate the mind-set of the builder, and may let us see how he determined the overall size of his vessel, and how he obtained the general hull shape he wanted, even if how the detailed shape was obtained cannot be recognised.

The information incorporated in the hull can thus be of great value in the search for early design methods, but care must be taken that the evidence is not manipulated to fit preconceived ideas that, for example, some legal unit or proportions of some modular unit had been used. Can the excavated evidence, and our measurement of it, bear the weight of the rules of thumb we believe we can identify, and the conclusions we would like to draw? Similar concerns have recently been expressed about claims of high precision astronomical orientations at prehistoric stone circles, and alignments of standing stones (Scarre, 2000: 375).

When considering what is known about early design methods, it is necessary to deal separately with hulls built plank-first and hulls built frame-first, since builders in one sequence have a different concept of hull shape from builders in the other (McGrail, 1995). It is relevant in this context to note that, during six seasons of fieldwork on traditional boats in the Bay of Bengal (McGrail, 2003), we found that more was learnt about design methods from frame-first builders than from plank-first builders. This may be partly because 20th century Europeans have a built-in affinity with frame-first methods which involve simple calculations and the construction of shapes; whereas we are often in uncharted waters when listening to plank-first builders describing what appear to be intuitative, unquantifiable techniques. Archaeologists may be similarly handicapped when trying to understand and interpret plank-first boat remains.

The design of hulls built plank-first

MEDITERRANEAN EVIDENCE

Steffy (1995a: 25) has noted that the hull shape of the Kyrenia ship of 300 BC was derived by determining the longitudinal shapes of the planks, setting them at just the right angles to their neighbours, & then fairing. Contemporary Greek geometry may have had some influence here, but, by and large, Steffy appears to be describing an art rather than a science: handed-on wisdom and personal experience would be needed to get those shapes and angles right.

Design aids do not appear to have been used, but Steffy (1995a: 25) has detected the use of ratios in the scantlings of several timbers in this ship. Such ratios are more concerned with relative strength than with hull shape, nevertheless, there is a hint here that ratios may also have been used to establish her overall proportions. The general shape of the Kyrenia hull may thus have been in the mind of the shipwright before work began, but it is not clear whether he could also visualise details such as the shape of individual strakes, or whether these shapes emerged as he progressed from keel to sheer strake.

Frost (1990: 183; 1997: 261) has argued that the design of the wreck, *Marsala 1* of *ca.* 250 BC, had been preconceived; and Basch (1972: 43–45) and Bellabarba (1996: 264) have suggested that moulds were used to get the detailed hull shapes of 5th to 3rd century BC Mediterranean warships. These arguments are not convincing. As with the Kyrenia ship, the general shape may well have been in the shipwrights' minds before work began, but none of these authors has demonstrated that, before garboard strakes were fashioned, these builders had visualised the details of that design, either in terms of the shape of individual strakes, or in terms of transverse moulds.

ATLANTIC EUROPE

Crumlin-Pedersen (1997: 14–15), quoting work by Godal on West Norwegian traditional boats, has suggested that, within the medieval Nordic tradition of building, detailed knowledge of how to control hull shape was handed on as basic rules incorporated in a code known by only a few. These rules were used to repeat a design, or to scale it up, or adapt it for different functions and environments, whilst remaining within the envelope of the Nordic tradition.

Partly worked, but unused, medieval Nordic stems have been recovered from bogs in Scandinavia & Britain: these were originally stored in ponds to stabilise the timber and keep it moist (MacPherson, 1877/8; Brøgger, Shetelig, 1971: 41; McGrail, 1998: 101). Bevels for the ends of strakes and curved lines representing strake runs had been worked on some of these stems. The builder must therefore have had in his mind the general shape of the boat, as defined by the plank runs, and also a detailed knowledge of the shape at bow and stern. How were such stems designed? Crumlin-Pedersen (1986; 2002) has observed that the curved outlines of *Skuldelev 3*'s stem are arcs of circles of radii proportional to the vessel's keel length: ⅔, ⅓, ⅙ (Fig. 20.2). He also noted that the lines of simulated planking on this stem tended to be arcs of circles, but a rule of thumb for these has not yet been established: such curves are more fundamental to hull design than the stem outline.

It may be that, in medieval northern Europe (as earlier in the Mediterranean), the general shape of hull was determined using proportions of a linear module such as the keel length. Since there is, as yet, no evidence for design aids before the post-medieval period, details of the design may have been expressed as 'rules of thumb': any such rules would, for example, have to define strake shapes similar to those illustrated in Fig. 20.3: the final form would then be achieved by eye, as individual planks were fitted.

One can see that such procedures could work for boats and small ships, but for a large, complex clinker-built ship of the late-Nordic tradition, such as the early 15th century English royal ship *Grace Dieu* (McGrail, 1993), these procedures would seem to be impracticable: further aids to control hull shape would appear to have been necessary. Steffy (1995b: 424) has voiced similar concern about the large Mediterranean ship wrecked off Madrague de Giens in the 1st century BC.

There are two design aids that, in theory, might have been used when building *Grace Dieu*:

(A) Possibly temporary moulds were used, or even designed frames, as Loewen (1997)has recently suggested for a contemporary of *Grace Dieu,* building at Bayonne in 1419. In this context it is relevant to note that late-medieval Chinese ships, which were probably built frame-first (on bulkheads), had edge-

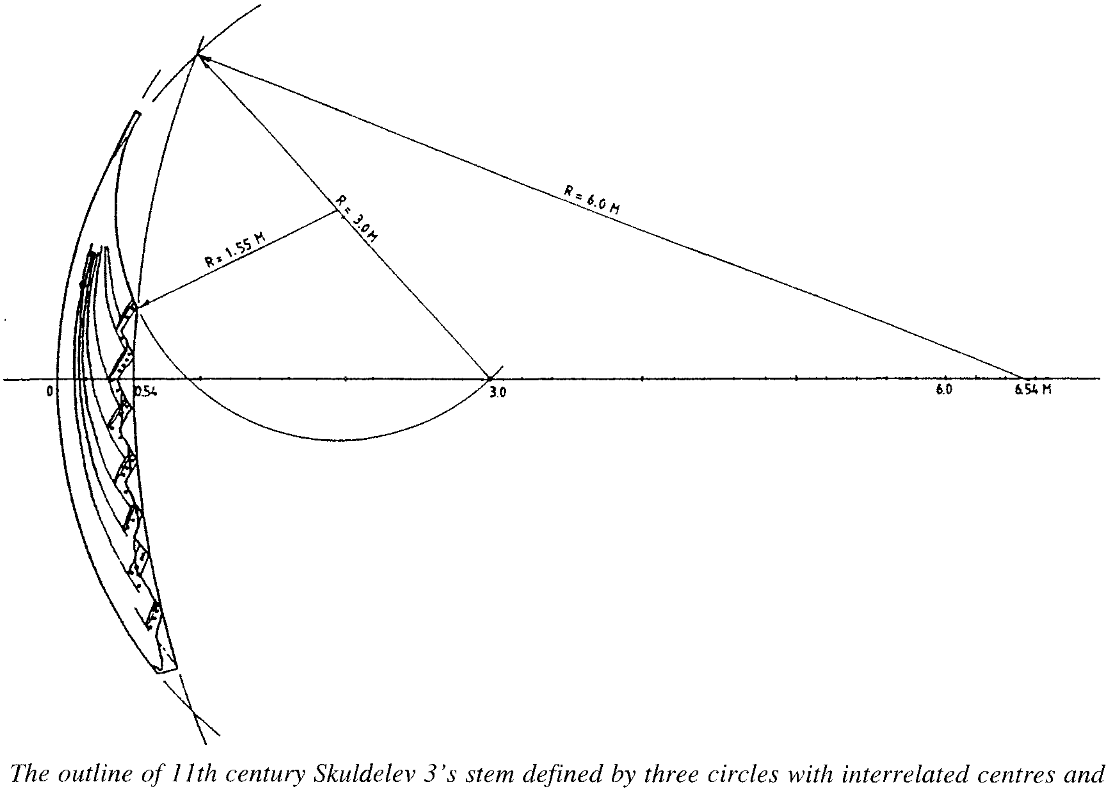

Fig. 20.2. The outline of 11th century Skuldelev 3's stem defined by three circles with interrelated centres and radii of 6 m, 3 m and 1.55 m (after Crumlin-Pedersen, 1986, fig. 5).

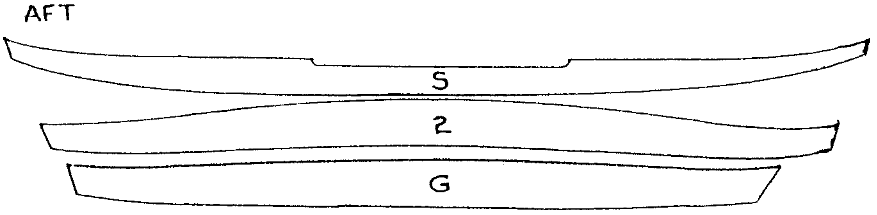

Fig. 20.3. Strake diagrams for the late 9th century Gokstad faering. G = garboard; S = sheer strake (after Mc Kee, 1972, fig. 2).

fastened planking (McGrail, 1996: 78–80 – see also the Appendix).

(B) Alternatively, hull shape may have been known as as a set of plank breadths and bevel or plank angles at selected stations. Such methods are known to have been used in later times in NW Europe (Christensen, 1972; McKee, 1983: 113).

ETHNOGRAPHIC EVIDENCE FROM SOUTH ASIA

In South Asia today, boatbuilding can still be found, seemingly not influenced by frame-first procedures (Blue *et al.,* 1997; Kentley *et al.,* 1999; McGrail *et al.,* 1999). The *patia* fishing boats of Orissa and West Bengal, and a group of traditional river boats of Sylhet District in NE Bangladesh have edge-fastened, reverse-clinker planking, and are built plank-first. Although work preparatory to the building of such boats could not be monitored during recent fieldwork, it seems most unlikely that they were formally designed. In answer to our questions through an interpreter, builders stressed their use of personal skills, and emphasised that they knew when hull shape was right. Proportions and other rules of thumb were mentioned, but it was not always possible to understand precisely how these were used, despite demonstrations.

A builder in West Bengal (Kentley *et al.,* 199: 155–156) quoted a rule-of-thumb giving the laps for the 10 or 11 reverse clinker strakes of a standard size of *patia* which was said to be 26 ell (11.89 m) overall length. Planks in strakes were all 6 inches broad and 1 inch thick (152 x 25 mm),and at any one station all strakes had the same overlap. The builder did not mention bevel angles or angles between strakes. When that rule is used to draw out a section, this idealised boat has a V-shaped lower hull, whereas real life *patia* are more rounded, due not only to bevels being worked on plank edges, but also to the use of varying breadths of plank. It seems therefore that this builder's rule of thumb was either not given in full, or that it was, at best, a general guide to hull shape.

In the Sylhet District of Bangladesh two sites were visited where reverse-clinker *Chhataki nauka* river boats were being built (McGrail *et al.,* 1999: 139). We were told that a standard boat here was also 26 ell in length, and 2 in breadth (11.89 × 0.91 m): boats had a nearboxlike cross section. Builders had two types of design aid: a measuring stick and a set of six bamboo sticks. The measuring stick, 44 inches (1.11 m) long, was marked with an un-numbered scale: it was used to check symmetry from an overhead centreline, and may also have been used to position the floor timbers on the boat's foundation (centre bottom) plank. The six bamboo sticks varied only slightly in length (265 to 290 mm): they were used to mark the necessary breadth of plank at selected stations along a suitable board. A line was then chalked through these marks, and the plank cut to this shape. There may have been comparable rules and aids in early Europe.

The design of hulls built frame-first

ATLANTIC EUROPE

The earliest known frame-first vessels are the seagoing vessels of the Romano-Celtic tradition from the 2nd to 4th century AD (McGrail, 1995). There are three of them: two ships, *Blackfriars 1* from the River Thames at London (Marsden, 1994), & *St Peter Port 1* from Guernsey (Rule, Monaghan, 1993); and an estuary boat from Barland's Farm on the Welsh side of the Severn estuary (McGrail, Roberts, 1999). It is convenient to use the boat to describe what is now known about Romano-Celtic design methods.

In the introductory section of this paper, six types of excavated hull data were identified which could point towards the mind-set of the builder. Four of those lines of enquiry proved fruitful in research on the *Barland*'s boat:

- two types of builder's marks were identified;
- from these, and from observations that the planking is not fastened together but only to the frames; that there is no sign that the planks were ever temporarily fastened together; and that planks within strakes meet in angled butts at frame stations, we can deduce the probable building sequence;
- from the frame spacing (centre to centre) a unit of linear measure has been identified: in our terms it is 0.56 m which could be the equivalent of two human feet: the actual ancient unit then would be one "foot" (28 cm);

- the radius of curvature of the lower parts of the frames has been estimated as three "feet", and the lower post as four "feet".

However, it has not yet proved possible to recognise (either in terms of the 28 cm "foot", or in terms of, say, the length of the plank-keel) a modular unit which might have been the basis for using proportions to determine hull dimensions.

It is clear that the detailed shape of the *Barland*'s hull (the rising and the narrowing) was determined by the framing, but we cannot suggest any simple rules of thumb, or any design aids, that might have been used to determine the precise shape of each of those frames. If, as seems possible, rules of thumb were used to give the initial shape of each frame, it seems likely that the final shape of the framing would have been determined by the builder's eye, and by fairing to flexible splines or to planks used as ribbands.

THE MEDITERRANEAN

Steffy (1994: 13, 85–91) has deduced the building sequence of the frame-first, early-11th century *Serçe Limani* wreck, from the waters of south western Turkey, and has identified a linear unit equivalent to 32 cm (now thought to be a variant of the Byzantine foot). Unlike the *Barland*'s boat, which has gracefully curving flared sides, the midships transverse section of the *Serçe Limani* ship is near-boxlike. Steffy has suggested therefore, that the shape of the lower parts of her two master frames could be defined by three straight lines: a line representing the floor measuring 6 units (1.92 m) each side of the keel, and rising one-eighth of a unit (40 mm) at each end; and two side lines representing the futtocks flared out at 18 degrees from the vertical, an angle readily constructed since the tangent of 18 degrees is *ca.*⅓. Side and bottom lines would then have been connected by a curve representing the turn of the bilge (Fig. 20.4). Steffy has also estimated the narrowing and rising of further active framing timbers which were added to the framework before planking began, but it is not yet proved possible to incorporate this information into a simple rule of thumb.

Nor is it clear whether proportions of some modular length were used to obtain the overall dimensions of the *Serçe Limani* ship. Builders of medieval cathedrals favoured proportions which can only be expressed as irrational numbers such as the "golden section" (1:1.618) or the square roots of prime numbers such as 2, 3 and 5. Lengths with these proportions are readily constructed from squares, rectangles, equilateral triangles and regular pentagons using elementary Euclidian geometry which became available in Europe during the 12th century (Stalley, 1999: 116–119). It is conceivable that such practices spread to shipbuilders, and therefore the search for proportions in medieval ship remains need not be limited to integers.

Although the *Barland*'s boat and the *Serçe Limani* ship were both built frame-first, it does not follow that their design methods and building sequences were the same. Not only are these vessels widely separated in time & in space, but also they are from different building traditions. For example, the floor and futtocks in the composite frames of the *Limani* ship are scarfed and fastened together; whereas the side timbers (futtocks) of the *Barland*'s frames are not fastened to their floor timber, although they both overlap it.

ETHNOGRAPHIC EVIDENCE FROM TAMIL NADU

Three types of boat (*vattai, vallam* and *vattal*), and two types of ship (*kotia* & *thoni*) of coastal Tamil Nadu are traditional vessels, built in wood and propelled by muscle power or the wind, yet they are built frame-first. In this they are unique on India's Bay of Bengal coast (Blue *et al.*, 1997; Kentley *et al.*, 2000).

In the Tamil design process, proportions of a modular length are used to determine other hull dimensions: for example, in the *thoni* ship the length of keel (L) is the unit and it is related in a known way to the cargo capacity of the vessel. At the station of the master frame, maximum beam (B) = L/4; depth of hold (D) = L/6.4: in other words L / B / D = 8:2:1.25. These proportions are changed slightly when motorised *thoni* are built, as now invariably happens. The rake of the posts is known as a table of offsets in the vertical plane *i.e.* – the tangent of the angle from the horizontal.

The design process involves drawing individual frame shapes full size, and is essentially the same for ships and boats. The only significant difference is that the *thoni mestri* works from the keel edge on a lofting floor, using a two-part mould (template), whereas, the *vattai mestri* works from the centreline on a scrieve board using a

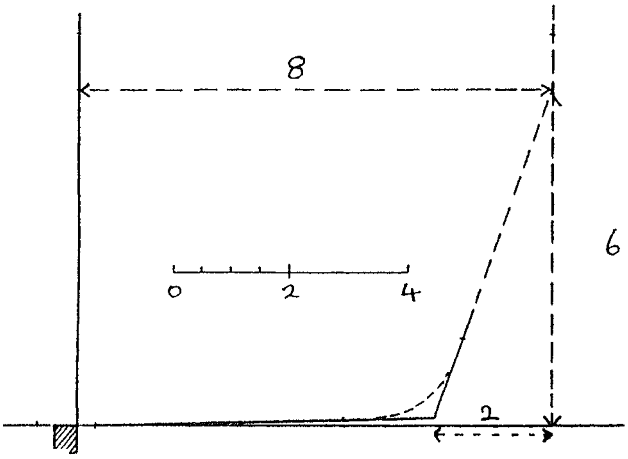

Fig. 20.4. Method of representing the outline of the 11th century Serçe Limani's midship frame. The scale is in "feet" of 32 cm (after Steffy, 1994, fig. 4.12).

single mould. A principal design feature is that the framing consists of four elements:

1) a master frame: its shape is given in the form of a mould;
2) a number of frames identical to the master frame: they are known in Tamil as 'equal frames';
3) a number of frames narrower and with greater deadrise than the master frame (known as 'unequal') – their several shapes are derived from that of the master frame by a rule of thumb and some elementary geometry;
4) a group of passive (not designed) frames at bow and stern.

The three-dimensional narrowing and rising of the hull of these vessels (that is, their detailed shape), is thus controlled by the two-dimensional shapes of the unequal frames. This design process is most readily understood in the case of the *vattai* fishing boat – see Fig. 20.5. At least two rules of thumb are in use to derive the shape of *vattai* unequal frames (Kentley *et al.*, 2000):

Dawood's rule: for every inch measured along the scrieve board diagonal, from the intersection of the last drawn frame, the half-breadth (on the diagram's upper horizontal line) is narrowed by 3/4 inch. – as in Fig. 20.5.

Sharif's rule: for every inch measured along the half-breadth of the boat (on the diagram's upper horizontal line) the diagonal measurement decreases by 1.5 inches for the first pair of unequal frames, by 2.5 inches for the second pair, and by 3.5 inches for the third pair. This rule produces a boat that is finer in the ends than a *Dawood* boat.

This Tamil design system has very much in common with the system used in late-medieval Mediterranean and Atlantic Europe (Rieth, 1996). In fact, the Tamil system appears to be a simplification of the European method to match the relatively simple Tamil hull shapes. It seems likely that a version of the European system was brought to India by the Portuguese in the 16th century, or by the French in the 17th (Blue *et al.*, 1998: 67–70).

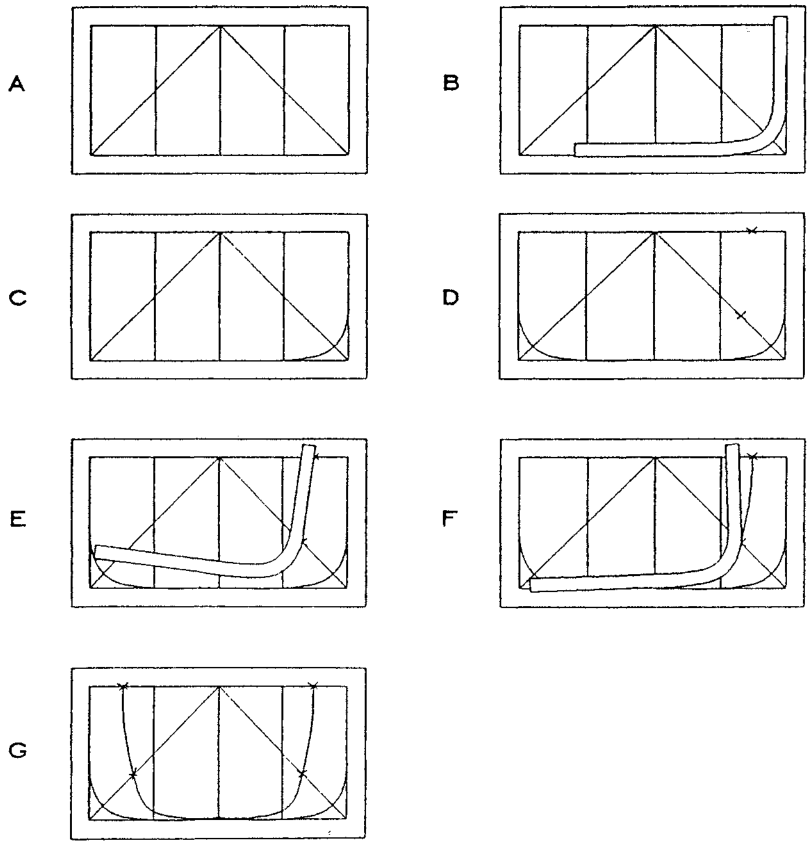

Fig. 20.5. Diagram illustrating the design of vattai frames using a scrieve board and a single mould (after Blue et al.*, 1998, fig. 13). A. Preparatory marking of scrieve board. B&C. Mould positioned to give one half of master frame; shape drawn. D. Mould flipped over and other half of master frame drawn. Points (X) marked on diagonal and on upper horizontal line, according to Dawood's rule of thumb. E&F. Mould positioned on the two points to give shape of one half of an unequal frame. G. Shape of an unequal frame marked on board alongside that of master frame.*

Discussion

It seems not unreasonable to suppose that there was once a time (well before the time range of this paper) when plank-first boatbuilding was entirely by eye. Today in certain parts of the world (again, outside the scope of this paper), at the other end of both the time scale and the technological spectrum, there are frame-first boats and ships built entirely from drawings and calculations. The evidence considered in this paper suggests that, in Europe from ca. 300 BC to ca. 1300 AD, a mixture of "by eye" and "by drawing /calculation" was used to control hull shape. Comparative evidence from 20th century South Asia suggests that rules of thumb and then design aids would have become increasingly used during this period. From this basis it is possible to hazard a two-part conjecture: the builder's experienced eye still had a large part to play in design during the later phases of European plank-first building, say 300 BC to 600 AD in the eastern Mediterranean, and say 1000 to 1300 AD in northern Europe. Nevertheless, proportions and other rules of thumb, modular units and possibly some design aids were used. Conversely, in the early phases of frame-first building, say 2nd to 4th century AD in north-west Europe, and say 7th to 13th century AD in the eastern Mediterranean, rules of thumb, simple geometry and other aids to design were increasingly used. None the less, elements of building by eye and the use of personal experience were still needed, not least when fairing a framework and working bevels on frames before planking, when determining the run of the sheerline (possibly aided by the catenary curve of a slack cord or a chain), and when spiling the shape of passive frames.

It follows from this that excavation may yet have its part to play in throwing light on medieval and earlier design processes: early design aids may survive to be excavated.

Appendix: Rules of Thumb from India, the Arctic and southern China

TAMIL NADU HIDE BOATS (PALMER *ET AL.*, 2001)

The *parical* of the headwaters of the River Kaveri is a hide-on-framework boat. Since it is circular in shape, the design of the framework is not complicated. The bamboo canes used are measured in ells; the dimensions of the boat, on the other hand, are specified in "feet", actual human feet of ca. 9 inches (230 mm), so that an "eight feet" boat has an actual diameter at its mouth of 1.9 m; and an "eleven feet" boat, is 2.57 m. Height of sides is generally said to be "two feet" *i.e. ca.* 0.48 m.

A rule of thumb determines the number of canes required for a given diameter of boat: for each "foot" in diameter, there should be three pairs of canes. In essence this rule treats the value of π as 3 rather *ca.* 3.1416.

ARCTIC KAYAKS (ZIMMERLEY, 1979; PETERSEN, 1982: 8)

Greenland and Hooper Bay kayaks of the 20th century were individually designed to match the person who would use them. These anthropometric measurements included:

- diameter of cockpit = armpit to first finger joint;
- overall length of boat = three × height of paddler.

CHINESE JUNKS (LIU, LI, 1991)

Traditional rules of thumb used to build 20th century wooden ships in Guangdong, southern China, have recently been published in the English language. It is not clear whether this account has been faired – as it were – by some academic, or whether it is direct from a shipwright. These vessels appear to have been built frame-first (actually bulkhead-first), nevertheless their hull planking was fastened together, flush-laid, with angled nails.

Modular length is (B) the waterline midships breadth.

Overall length (L)	= 4B (coastal) or 6B
Depth of hold amidships (D)	= B/2
Height of bow	= B
Height of transom stern	= 3B/2
Deadweight (cargo capacity)	= LBD/3

Rake of stempost is given in offset or tangent terms. Heights of mast are multiples of (B); and the size & shape of sails are also related to (B) through the height of their mast.

Length of the rudderpost	= B
Rudder area	= $(B/2)^2$
Length of leeboard	= B
Breadth of leeboard	= L / 20 (*i.e.* B/5 or 3B/10)

Other rules of thumb include:

Length of plank-fastening nails	= 2 × plank thickness
Nail spacing	= nail length

It is not difficult to visualise versions of these rules being used in China in earlier times.

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21. The Hogendijk Shipyard in Zaandam and the VOC Shipyard Oostenburg in Amsterdam. Examples of Recent Archaeological Slipway Research in the Netherlands

Jerzy Gawronski

Introduction

For the past forty years, the archaeology of maritime culture has focused on ships and shipwrecks. This attention is now shifting towards their places of origin, the yards where ships were constructed and equipped. This paper aims to contribute to this specific field by presenting recent examples from two shipyard excavations in the Netherlands. The first is the Hogendijk site in Zaandam, where fieldwork was organised in 1998 by archaeological consulting firm Hollandia in co-operation with the Amsterdam Archaeological Centre of the University of Amsterdam on behalf of the city of Zaanstad and the Province of North Holland. The second site presented is the Oostenburg site in Amsterdam where the Dutch East India Company's (VOC) shipyard was located. The first archaeological research here was organised in 2000 by the urban archaeological unit of the City of Amsterdam (afdeling Archeologie, dienst Amsterdam Beheer).

The Hogendijk site contains a number of slipways that have yielded the first archaeological data regarding late 16th century and early 17th century shipbuilding facilities in Zaandam, a town located north of Amsterdam along the River Zaan. In the 17th century, an extensive park of saw-windmills spread along its banks making it the centre of the Dutch timber sawing industry. It was simultaneously the nation's main private shipbuilding region. Historical data on the development and layout of the wharfs is scarce (Lootsma, 1939; Braam, 1992; 1998) and systematic urban archaeological research in this area is in its preliminary stage (Fig. 21.1).

The Oostenburg site is a large-scale yard and storage facility which was the core of the Amsterdam VOC

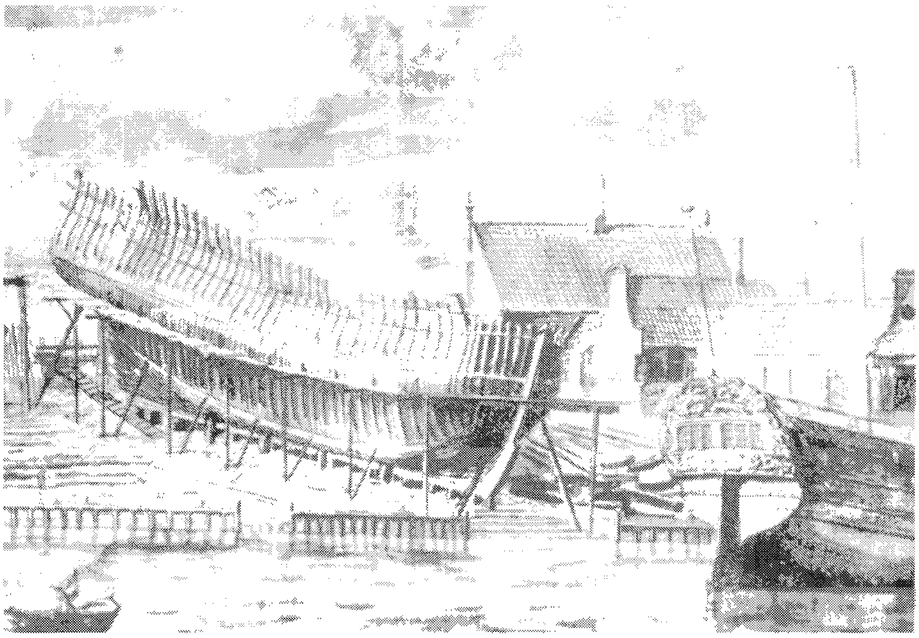

Fig. 21.1. A 17th century shipyard on the Hogendijk along the river Zaan (anonymous drawing: Municipal archive, Zaandem)

shipping system. The yard was developed in the 1660s and produced many seafaring vessels for the VOC right up until its closure in 1799. In the 19th century the complex remained in use for Navy gun storage and the industrial production of steel vessels and steam engines. Later, in the 20th century, trains and fuel engines were produced here. The archaeological research was limited to a small section of the former yard, which yielded information on the 17th century layout and the VOC's technical and engineering principles (Gawronski, 2000) (Fig. 21.2).

As a general outline and to stimulate further discussion regarding the archaeology of historical or pre-industrial (16th to 19th centuries) shipyards, this paper will briefly address their typical multi-layered meaning as an important feature and research asset. Essentially, ships and shipyards can be considered as material sources with clear parallels between them. Both structures contain multiple functional and symbolic meanings that are defined by a similar historical maritime context. A shipyard, for example, can be considered as a workplace, a distribution centre, an artisanal workshop, a production complex, an assembly plant or a meeting location. Such a multi-layered definition is a basic theoretical starting point for archaeological research and the integrated historical interpretation of shipyard material remains. It is from this perspective that the Oostenburg yard is discussed because of its well-documented context in relation to the VOC enterprise. Finally, this paper will present the preliminary excavation results of both the above mentioned sites. The focus will be on the construction and layout of the slipways which were found. Each location covers a distinct phase in the late 16th and the mid-17th century development of shipbuilding facilities in the Netherlands.

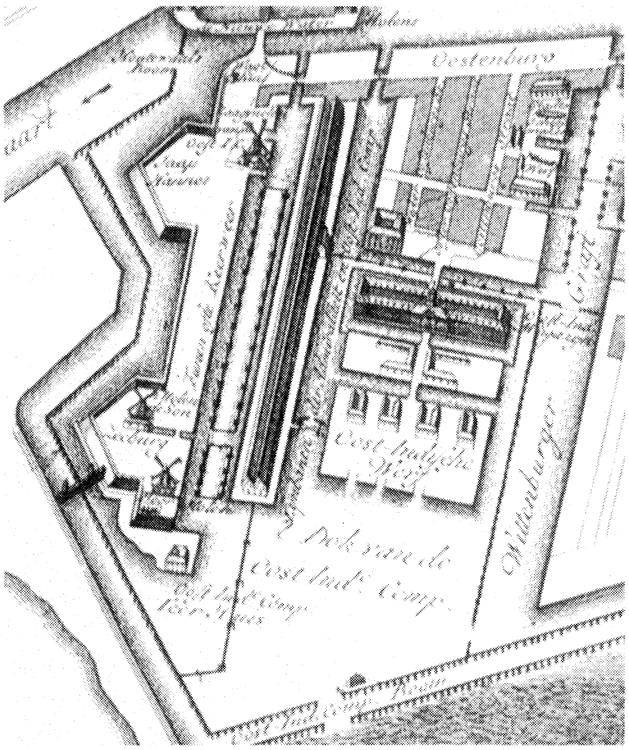

Fig. 21.2. The island Oostenburg next to the eastern ramparts of the city of Amsterdam which housed the VOC shipyard (C.P. Jacobs, 1766)

Shipyard research

Historical shipyards seem to be rather underdeveloped features in archaeological research. In academic as well as national research programs both in and outside Europe, these sites are rarely dealt with in a systematic way. It appears this situation has arisen for a number of reasons.

First, this type of research requires a water-oriented archaeological reasoning. This approach relates to both the physical aspects of work in an aquatic environment and, more importantly, is based on the material concepts of maritime culture represented by ships, ship structures or ship equipment. Historical shipyards are often found nowadays in urban areas or in wet locations along riverbanks or harbours at the transition of land into water or can even be found on terrains which are drowned and now located under water. When the former yards are located on reclaimed land and the waterfront is pushed forward beyond the former yard, the subsoil structure as well as the stratigraphy are still characterised by water effects and water works. Although all excavations are based on universal rules of documentation, the analysis and interpretation of sites with remains of ships and shipbuilding facilities demand a specialised method and particular knowledge. These waterfront areas have generally been neglected by 'land' archaeologists, who were more focused on the typical material culture of urban history or rural development and who lacked a specific maritime orientation. 'Marine'archaeologists who were accustomed to fieldwork in or near water and had expertise in maritime culture, generally paid little attention to shipyards. For the past thirty years they have been fully concentrated on developing underwater and maritime archaeology into serious scientific disciplines. As diving projects were organised, archaeologists headed for the water without paying much attention to the shores. Successful worldwide excavations in oceans, rivers, and lakes were producing an ever-growing pool of archaeological data on ships, harbours, trade, transport, discoveries and expansion. Ships were being redefined as intricate and meaningful satellites of human society instead of romantic shipwrecks with fascinating secrets and hidden treasure. Shipwrecks became new multidisciplinary sources of information which, when coupled with available historical sources as images, documents and models, proved to be extremely valuable. While knowledge on ships grew, some blank spots remained in other fields of research, such as the place of origin of these floating structures, namely the shipyards.

Second, a more circumstantial reason for the lag in research is the process of 19th and early 20th century industrialisation. Shipyards are often part of industrial areas which stayed operational throughout the 20th century. By definition, these are restricted areas without public access. Presently, as a result of urban development and specifically because of the re-use of characteristic waterfronts or harbours, these areas are increasingly developed within the urban landscape to host a combination of functions such as housing, work and recreational facilities. The historical identity and functional continuity over several centuries give these former shipyards a surplus value in the present cityscape. As a result, archaeologists now have more opportunities to excavate historical and pre-industrial shipyards. To use this opportunity to its full extent and to develop an optimal research model, a synthesis of ship, historical and urban archaeology is necessary, focusing on a shipyard as a material and historical source in an urban (or originally proto-urban or rural) context.

Multilevel information

Due to its close connection with VOC ships and the historical VOC enterprise, the Dutch East India Company shipyard in Amsterdam is particularly appropriate to illustrate this evolution towards a multidisciplinary approach. Since the early 1960s, VOC ships have held a prominent role in the development of underwater archaeology. These shipwrecks drew international attention because of their close link with East India trade and Dutch maritime history. They also represented all the allure of exotic tales involving shipwreck and disaster, possible hidden treasure and its financial rewards, the museum potential of material remains and rich sources of archaeological information. A relatively large number of these wrecks have been found. In nearly forty years some fifty sites have been discovered, triggering numerous commercial salvage enterprises and scientific projects. Despite the methodological and theoretical confusion arising from this hectic outburst of activity, as well as the diversity of the sites, the contours of a homogeneous research field started to appear. Historical study on the common identity of these ships, which was dictated by the shipping business of the VOC, provided archaeological coherence (Bruijn, 1979–1987). VOC ships are material and historical sources which combine a special find-complex under water with a specific company's archive. Historical-archaeological research provided the key to integrate the rich variety of details. This approach facilitates the development of meaningful discussion regarding the interpretation of the individual sites within a more broad and social context and thus providing the outline of a proper research field. This analytical process in the 1980s and 1990s led to functional modelling of VOC ships as *pars pro toto* components of the company, each individual ship theoretically comprising a microcosme of the different features of the total enterprise in Europe and Asia. A number of projects, especially the *Hollandia* (1743) and the *Amsterdam* (1749), contributed to the development of such historical archaeology theory of VOC ships (Gawronski *et al.*,1992; Gawronski, 1996). This also created greater consciousness regarding the meaning of the shipyard as a similar source of the VOC policy and its material implications .

The VOC-shipyard as central place

The Oostenburg island yard served as centre stage for intensive ship production and distribution (Fig. 21.3). In some 150 years approximately 720 ships were built in Amsterdam, of which the largest part (about 500) was on Oostenburg. With at least fifteen vessels leaving Amsterdam annually, the yard was the starting point (or end point, depending on the direction of the journey) of the intercontinental bridge of ships, which supported the company's over-sea administrative and communication system and transport and trade lines. Upon arrival from Asia, the imported goods were stored and processed on the harbour island of Oostenburg: spices, stimulants, porcelain, textiles, monopoly-goods and exotics, bulk-articles and rare products. Even more importantly, the yard was a focal point of hundreds of supply lines. As a self-generating machine, the production complex had to be fed by its surroundings: the city of Amsterdam. This international trading metropolis was a gathering point for thousands of products, not only from regions throughout Europe but from the entire world. This was the VOC's source for building and equipping ships. Trading houses, shops, artisans, workshops and factories, in brief several hundred people were engaged in supplying the Oosten-

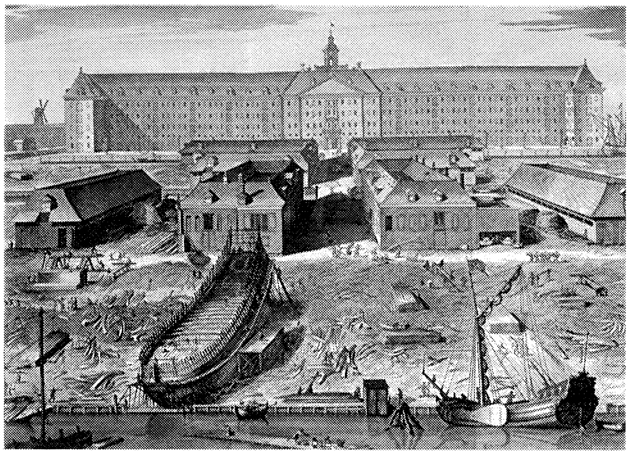

Fig. 21.3. The VOC shipyard seen from the harbour: on the foreground one of the slipways and at the rear a number of utility buildings and the massive sea warehouse (print by J. Mulder, mid-18th century).

burg yard. In the mid-18th century, more than 600 suppliers were contributing annually to the yard's production system. Oostenburg as receiver and transmitter is a basic yet essential metaphor, mirroring the VOC itself. Here, within the confinement of the yard, was the core of the Dutch branch of the enterprise, operating within a distinctive European context. As the focus of the Amsterdam trading system, the yard used products from all neighbouring European regions. A brief list of supplies clearly illustrates its international scope (excluding the local and regional Dutch products): timber from Scandinavia, Poland and Germany, tar from Russia, hemp from Riga, iron nails and fittings from Liege, glass from Bohemia, quicksilver from Austria, copperware from Nurnberg, wine and liquor from France, Germany, Spain and Portugal, iron guns from Sweden, trumpets from Leipzig, pewter spoons from London, cantharidum from Spain ('Spanish flies'), octants from England, oxen from Denmark, butter from Ireland, grain from Prussia and Poland, prunes from France, fish from Norway. All this material was transformed on Oostenburg into loaded ships, which maintained the oversea branch of the VOC.

The VOC shipyard and pre-modern manufacture and production

Not only was its material structure large-scale and intricately woven, but similar principles seem to have been applied to the labour organisation and the logistics of the working floor. In 1750, 1200 employees manned this section of the VOC: some 80 staff and 1100 workmen. The organisation consisted of six main sections: administrative staff, artisanal departments, storage, transport, vessels and barges, and a security system. The structure of the organisation was pyramidal with a small staff of three bookkeepers at the top, while the broad base consisted of a finely crystallised network of subdivisions and separate working units. Some fifteen main artisanal labour units can be distinguished next to an administrative staff of 65 specialised functions. In fact, the yard consisted of a series of independent and specialised sections which can be seen by the division and allocation of tasks. This horizontally organised labour clashes with the general image of the VOC organisation, symbolised by the hierarchical structure of the board of 'Seventeen' (Directors). While the oligarchic bureaucracy of seventeen regents seems archaic, a functional analysis of the daily work indicates the organisation of the yard was almost modern, in view of the standardised and efficient assemblage of mass-products in wood. Instead of the traditional energy sources of wind, man and animal power, the 19th century industrial technology of steam and steel would have fitted well with the 18th century production system of the VOC yard. The functioning of the VOC is typical of pre-modern Dutch ship production. This phase started at the end of the 16th century with the birth of the maritime expansion period and ends at the threshold of the industrial revolution at the end of the 18th century. The historical data on organisation and functioning lead to questions regarding the material aspects of this process: data was required on features such as infrastructure, spatial environment, functional planning, technical facilities, utility buildings, technology and material culture. In this context the archaeology of shipyards can contribute to knowledge and introduce a view of specific aspects of cultural and economic processes of historical societies.

Archaeological case study: Hogendijk late 16th–early 17th century slipways

The Hogendijk ('High Dyke') site is located at the north end of the sea-dyke along the river Zaan which protected the hinterland against flooding. During the 17th century, Zaandam (20 km northwest of Amsterdam) became the 'industrial' centre of the Netherlands where the timber, whaling and shipbuilding industries boomed. There were two main areas of activities: the Binnenzaan (Inner Zaan), closed by a dam with locks and a portage, and the Buitenzaan (Outer Zaan), the open part of the river with a connection to the Zuiderzee (the inner sea of the Netherlands), whose western shore is defined by the Hogendijk runs. A distinctive feature of the site is its location outside the dyke which was constructed around 1300. The terrain was unprotected against flooding from tides and storms, and was gradually reclaimed from the water by subsequent raising of the soils. In general it is believed that shipbuilding developed in the inner river and spread from there to the Outer Zaan. Precise historical information is scarce on the early size and organisation of shipbuilding and hardly any data is available on the logistics and infrastructure of the yards. The first activities are mentioned in the end of the 16th century. There is a sudden rise in the quantity and quality of ships produced in the first half of the 17th century. With a shift from repair to new building, vessels become larger and the production of small inner-water vessels and fishing craft is replaced by the construction of 120–130 foot seafaring vessels for transport, commerce and warfare, such as the 'fluit', the highly successful bulk carrier of the 17th century. The number of shipyards along the Zaan increased tremendously from approximately 22 in the 1630s to some 60 in the 1650s. The shipbuilding centre shifted from the inner river to the 'Buitenzaan'. By the second half of the 18th century, the formula of cheap production by relatively small companies with low-cost materials and a limited number of ship types was no longer successful. Zaandam could not compete with foreign yards, where new designs and tational scientific approaches were introduced. The role of Zaandam as the major Dutch ship production centre came to a definitive end as the river's silting-up process increased. Although the waterfront became less accessible, ship construction sites remained in use until recently at the end of the 20th century.

The urban redevelopment of a site along the river at Hogendijk provided the opportunity to excavate in this historic shipbuilding area (Gawronski *et al.*, 2000; Dautzenberg *et al.*, 2001) (Fig. 21.4). Despite the time pressure of the rescue archaeology operation, evidence for a more precise chronology of shipbuilding development and the technology of the facilities was found. The visible remains on this site consisted of three historic houses along the dyke dating from the 18th century and originally built around 1650. Here evidence was also found for a predecessor, representing the first habitation of the outer-dyke riverbank area dating back to the last quarter of the 16th century. This earliest brick and wood house was built on an artificial mound of clay sod or blocks. It was part of a system of isolated mounds with individual houses, developed at the end of the 16th century. Against the mound, refuse layers of wood chips were deposited, containing shipwright's tools and pointing to shipbuilding activities along the dyke. This production refuse was used as a filling layer to reinforce and raise the soil and also create more working space. By 1650 the individual mounds were connected together as one building area, with a space for several shipyards behind the newly built houses. The development of these yards coincided with the historical boom of shipbuilding activities. Archaeological remains of these shipyards appeared to be eroded because of later building and land use activities which continued till the present day. However, substantial structures related to slipways from the earlier phase prior to 1650 were still preserved. In total, the remains of four slipways were recovered, at intervals of approximately 40 m along the dyke, each situated behind an individual mound with a house against the dyke. They were built on an artificial slope of raised clay soil and consisted of a wooden floor structure founded on a substructure of beams. All four dated from the same period of about 1575 to 1650 and reflected identical construction principles. Analysis of the structure of the most intact example (slipway B) yielded detailed information on the general construction of all four slipways and their repairs. The recovered plank floor was 8 m wide, 18 m long and originally had a total length of 30 m. The average floor slope was 10°, but over the last 5 m the downward bend increased abruptly to 23°, producing a strong tilt towards the water. On either side of the floor was a vertical board of horizontal planks, creating a boxlike wall at its lower downward sloping end. The slipway was almost entirely composed of timbers from demolished ships: the floor was made from hull planks, the foundation was a mix of different heavy and broad timbers, predominantly from ships, such as stem and stern

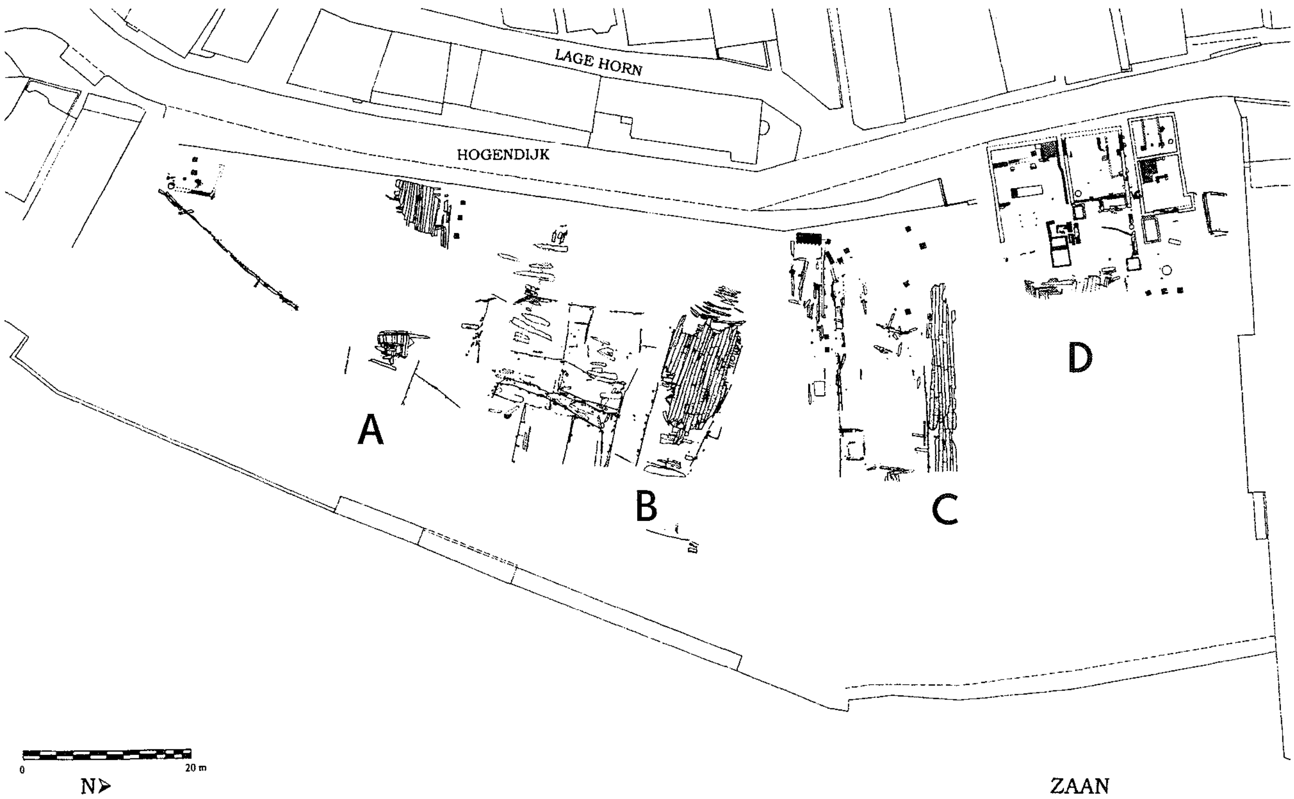

Fig. 21.4. The Hogendijk site on banks of the river Zaan. The remains of four slipways (A-D) were (partially) excavated as well as several late 16th to 18th century houses along the dyke (plan: Hollandia archaeological consultants).

sections, keel elements, beams and frames, with some elements from building structures (Figs. 21.5–21.6).

Three separate levels could be distinguished, whereby each layer of foundation beams was placed directly on the previous plank floor, which was covered by only a thin layer of sand or clay. Apparently the subsoil did not provide enough stability for the slipway. It sank into the riverbank under its own weight and from the pressure of ships under construction. After a time, the slipway floor had to be raised and a new foundation of beams was needed.

A small number of artefact finds under the floors and between the beams, in combination with dendrochronological data of the timbers, provided clues for dating. This data shows a sequential process of regular renovations about every 25 years: the youngest phase of the slipway use was 1625–1650, the preceding phase was 1600–1625 and the oldest and first phase was approximately 1575–1600. After 1650 the upper platform of planks was covered with wood chips and clay sods, indicating that the slipway was filled and no longer in use by the second half of the 17th century. Because of its construction and renovation, the slipway proved to be an important source of dendrochronological information on late 15th, 16th and early 17th century ship timbers. During the excavation a total of 170 oak and pine samples were taken, of which 95 have been analysed. Of these, 71 samples produced a dating, 34 of which were related to the most intact slipway. Half of the dates were felling dates (with a margin) and the remaining half were *post quem* datings of the timber cutting. The dendrochronological analysis only provided relative datings for the construction of the slipway. As the timbers had originated from demolished ships, a supplementary margin of at least twenty to thirty years has to be taken in consideration in applying this data to the slipway's construction. The dendrochronological datings roughly cover a broad period from about 1500 to 1650 and proved to be in general considerably older than the periods of slipway construction. Despite their general chronological discrepancy, the felling dates showed a relative clustering

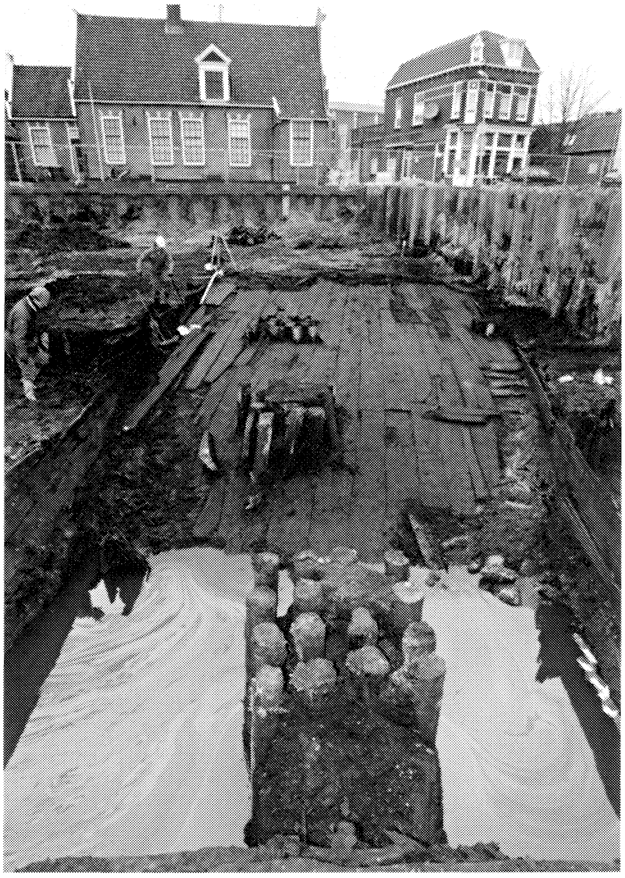

Fig. 21.5. Slipway B: upper layer of planks belonging to the floor of the youngest phase (III): the clusters of vertical pile belong to the foundation of a recent building (photo: Hollandia archaeological consultants)

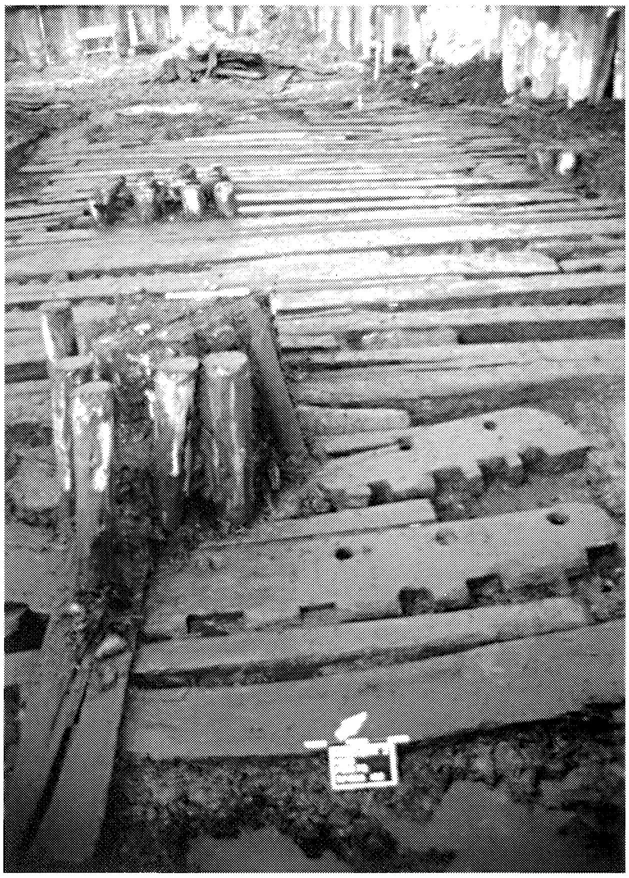

Fig. 21.6. Slipway B: timbers used as foundation beams to support the upper layer of planks (phase III)(photo: Hollandia archaeological consultants).

pattern in relation to the constructional phases of the slipway. The oak timbers used for phase I of the slipway (1575–1600) were cut in the first half of the 16th century (planking about 1565, beams 1540–1570). Those for phase II (end 16th– beginning 17th century) were cut in the second and third quarters of the 16th century (planking 1550–1590, beams 1540–1560) (Figs. 21.7–21.8).

The felling of the timbers for phase III (1625–1650) took place at the end of the 16th century and the beginning of the 17th (planking 1620–1640, beams 1580–1590). Apart from the relative dating a clear shift in the origin of the timber was visible in the three different phases. In the first phase all timber was of German origin, while in phase II not only German timber beams were used, but also planks and beams from the South Netherlands and Belgium region as well as from the eastern Netherlands along with Westphalia and West Germany. Furthermore, the first wood from South Sweden with a relatively young felling date of about 1590 appeared. The use of timber from the South Netherlands and Belgium stopped after 1580: the last exact felling date of this category of timber was 1579. Possibly the change in timber availability or shipping movement is related to political developments in the region and more specifically to the military tension

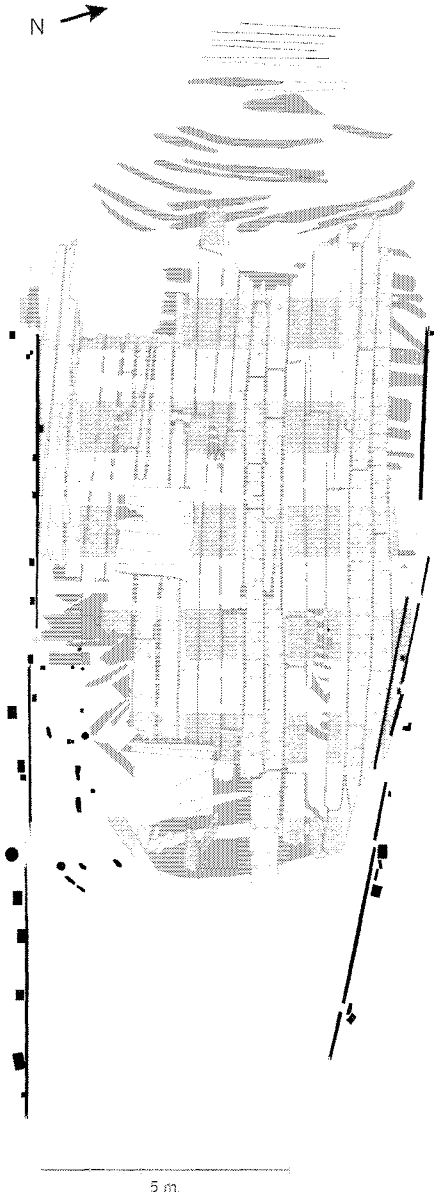

Fig. 21.7. Slipway B: plan of the second floor (phase II), also composed of re-used hull planks (Hollandia archaeological consultants).

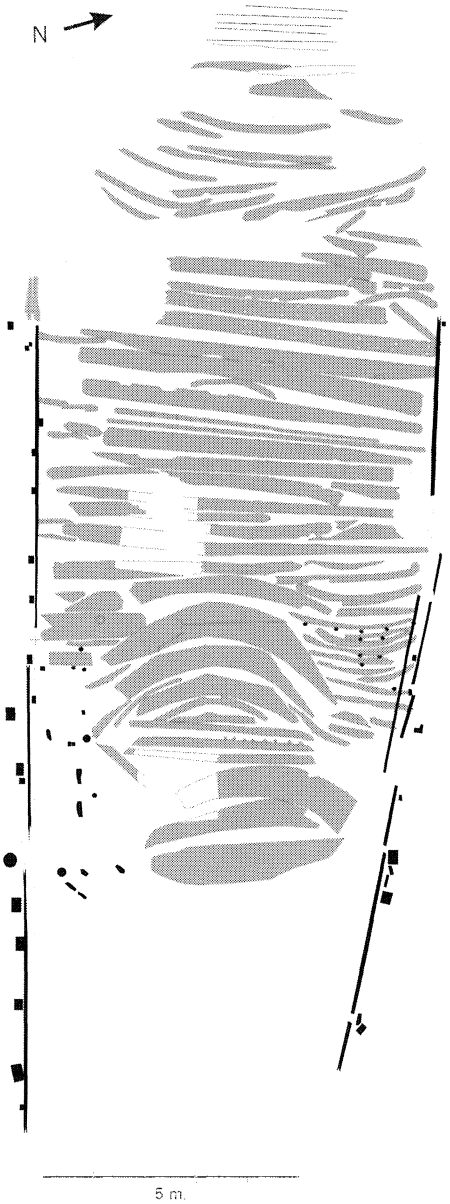

Fig. 21.8. Slipway B: plan of the foundation beams of the second floor, comprising several stem sections (phase II)(Hollandia archaeological consultants).

as a result of the revolt of the North Netherlands against the Spanish empire based in the South Netherlands. In phase III most of the timbers came from vessels which were built in different regions: the planks originated mainly from Poland, while the beams came from South Sweden. The present dendrochronological data do not allow any conclusions on timber trade or the supply of wood to the Zaandam area during the early stage of shipbuilding at the end of the 16th century and the beginning of the 17th century. As the slipway was constructed of recycled timbers, these data refer to ships which were demolished along the Zaan. Assuming that the place of construction of these vessels is related to the timber origin, the wood analysis shows that apart from vessels from the North and West German region, around 1600 vessels from the Baltic region (South Sweden, Poland) were laid up at the Zaan. Their timbers provide indirect proof of shipping contacts between Zaandam and these European regions.

Preliminary technical analysis of the timbers resulted in the identification of several constructional elements, which are unrelated to each other but provide data on structural features of individual ships in addition to the identification of their origin and their dendrochronological dating. The timbers belong to several types of small sized vessels, like 'waterships', fishing craft or cargo vessels for Dutch inland navigation. Some of the stems showed double rabbets for doubled outer planking and some frame fragments were cut for clinker-built hulls. An interesting find regarding 16th century Northwest European timber trade and ship production is a stern post (approximately 5 m long) of a clinker-built cargo vessel of approximately 100 feet long. The timber was of Polish origin and cut around 1540: three draughtmarks are in Amsterdam feet and suggest a vessel which had been used and possibly manufactured locally.

In conclusion, the excavation produced some important results renewing and refining the historical theory of shipbuilding development in the Zaan area (Fig. 21.9). The presence of the slipways and landfill of shipbuilding refuse proves that shipbuilding developed earlier than assumed on the river Zaan's outer banks. In the second half the 16th century, four slipways were constructed in connection with individual habitation-mounds outside the sea-dyke which were big enough to produce inner water vessels as well as medium sized seafaring ships up to 30 m long. The slipways were composed of timbers from laid up ships which were probably in large part produced outside the Zaan area in the German and Baltic regions. Hull planks were used for a sloping floor which was supported by timbers. The foundation timbers were arranged in tight rows and were put flat on a slope of soil. A slipway could consist of several floor layers, which appeared to be renewed in an improvised and ad hoc way. Because of the marshy nature of the clay slope, the slipway apparently sank into the soil and had to be raised regularly. Every 25 years the floor was refurbished by merely adding a new layer of beams and floor planks on top of the previous floor. This type of slipway became obsolete in the middle of the 17th century. The entire terrain was raised and extra land was reclaimed to provide space for new and probably larger shipyards as construction reached its peak along the Zaan.

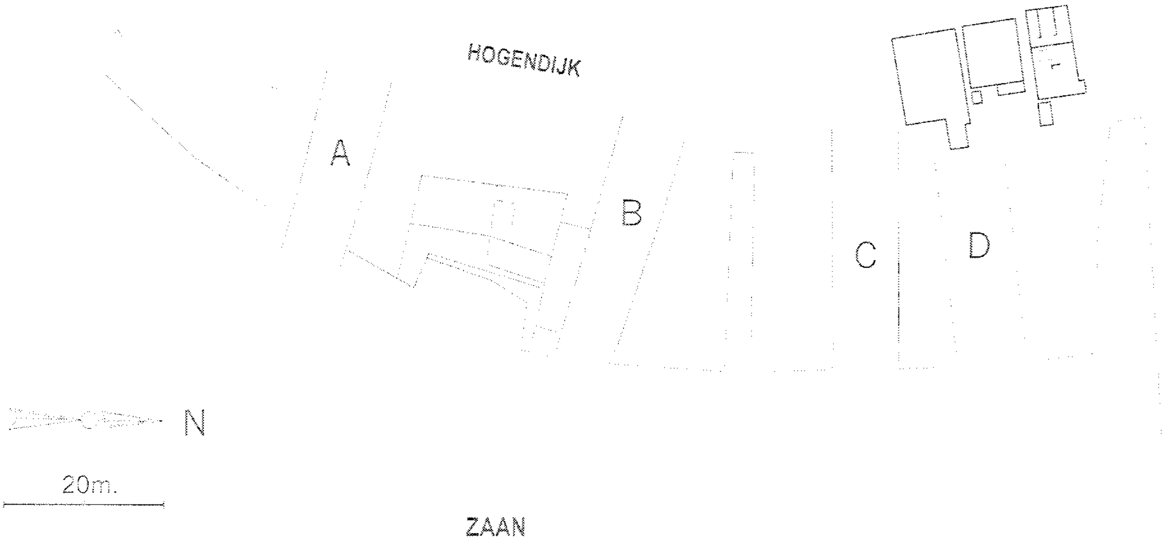

Fig. 21.9. Reconstruction of the mounds with the four slipways along the Hogendijk at the end of the 16th century (Hollandia archaeological consultants).

Archaeological case study: a VOC slipway from 1660

Chronologically, the shipbuilding facilities of the VOC in Amsterdam offer a perfect transition from the early 17th century Hogendijk ship production to the late 17th and 18th century shipbuilding for the East India trade. The VOC yard was conceived as part of an urban development scheme between 1640 and 1670 to extend the eastern boundaries of the city of Amsterdam and to create three artificial harbour islands: Kattenburg, Wittenburg and Oostenburg. Oostenburg was reserved for the East India company which constructed the new shipyard in 1660–1665. Essentially, the VOC facility consisted of three islands which were connected to each other and contained a series of utility buildings and structures for specific purposes (Kist *et al.*, 1986). The layout and building scheme of the islands reflect the concentration of labour and the division of working units within the complex. The main building was the 'Zeemagazijn' (sea warehouse) on the first island, with a central gate providing access to the other islands. It was a multifunctional building used for storage, distribution and processing of provisions, equipment and merchandise, one of the largest structures of its kind in the 17th and 18th century (215 m long, 30 m wide, 7 stories high).On the second island were two workshops for the manufacturing of masts, sloops, gun carriages and wooden rigging parts. The third island contained four buildings with a forge, an iron products storage, a pharmacy and the ship carpentry workshop, and the actual building area for ships. Here along the north bank of the island were three slipways. Contemporary information on the shipyard's technical facilities is scarce: some plans with the general layout are available and a number of prints and paintings offer iconographic data on its buildings and installations. Apart from the main buildings, most of the utility facilities consisted of semi-permanent constructions of wood or earth, which could easily be adjusted to changing needs and lack detailed historical documentation. The slipways, for example, are generally indicated on the plans as an oblong rectangle consisting of two simple parallel lines. Archaeological research in this terrain aimed to collect exact data on the specific facilities and yard arrangements. Excavation was limited to an area where originally the island's north harbour bank with possibly one of the slipways were situated. The harbour was reclaimed in the 19th century and is at present part of a large industrial complex. During the archaeological research the former shoreline was traced, thus providing fixed marker points to relate the present industrial building environment to the historical topography. Together with the vertical planks of the harbourbank lining, a large wooden floor of 12 m wide and 50 m long was also uncovered (Fig. 21.10). The floor planks were beechwood and were supported by a heavy pine beam at every meter. Each beam was founded on 12 piles which were tenoned into the underside of the beam. 19th century building activities had damaged the floor installation: over a length of 20 m the beams and planks were removed and only the foundation piles remained.

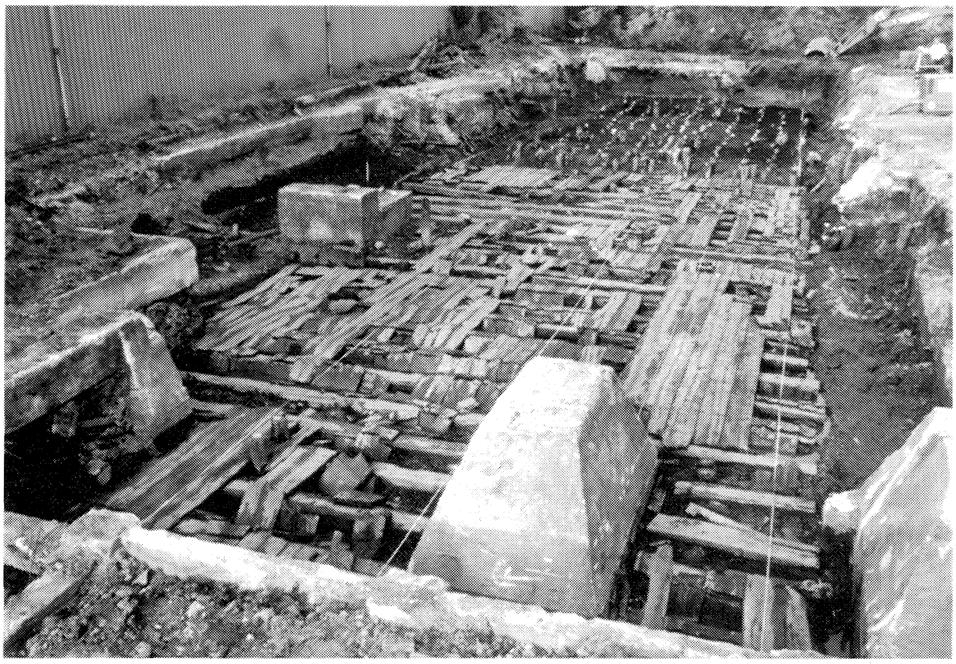

Fig. 21.10. The foundation floor of the 1660 slipway on the VOC shipyard seen towards the former harbour bank: the planks survived at the rear end over 30 m, but in the first 20 m only the foundation piles remained (photo: afdeling Archeologie, Amsterdam: W. Krook).

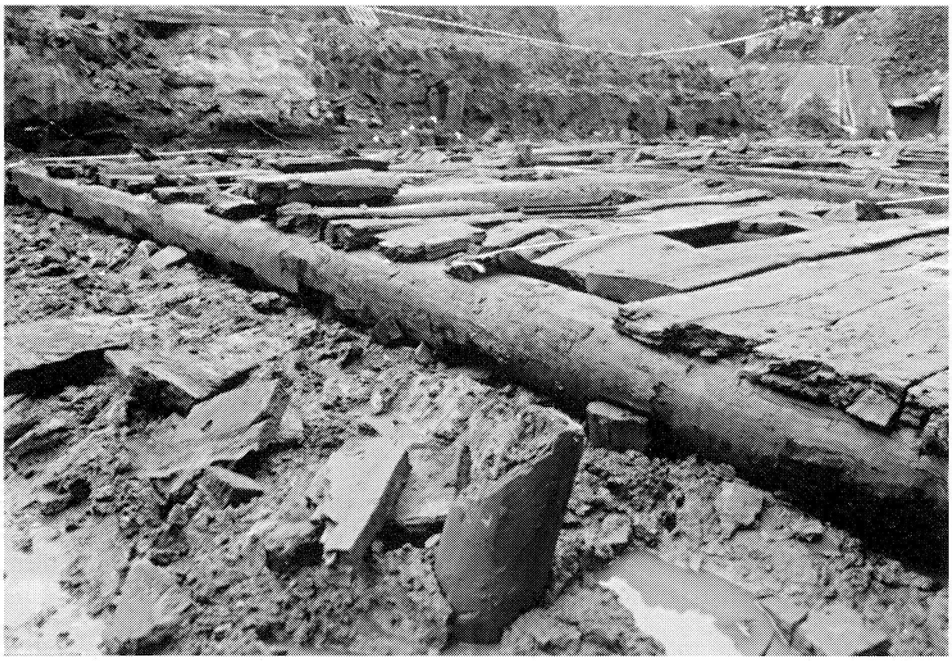

Fig. 21.11. One of the twelve meters wide foundation beams (photo: afdeling Archeologie, Amsterdam: W. Krook).

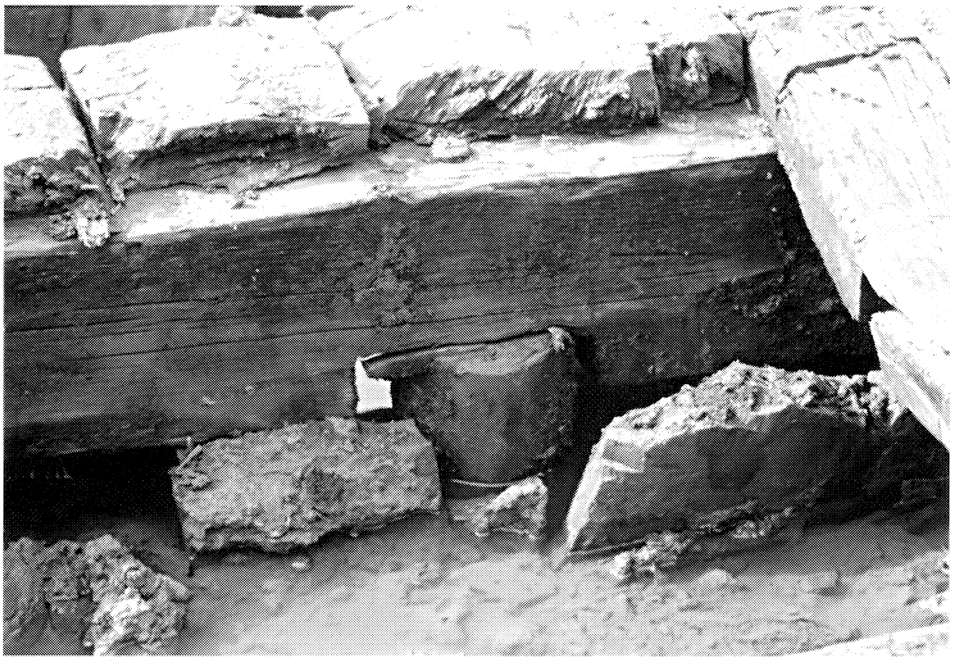

Fig. 21.12. Detail of the mortice underneath the beam to fit the foundation pile (photo: afdeling Archeologie, Amsterdam: W. Krook).

Several features support the identification of the wooden structure as a slipway (Figs. 21.11–21.12). Its location fits with the general cartographic information on the layout of the yard. The floor was located in a straight angle to the harbour bank and was connected to the shore, providing access to the water. Its foundation was heavier in the central axis with three piles grouped together to support the weight of a ship resting on its keel. The central axis was also reinforced at the shore line with more heavy piles to resist the increasing pressure to the shore end of the slipway floor during the launch of the ship. Dendrochronological analysis of the beechwood showed that the planks of the floor belonged to one shipment of tree trunks, which originated from South Germany and were cut in autumn 1659. Taking into account the duration of transport and processing of the trunks, this felling date fits exactly with the historical scheme of 1660–1665 in which the Oostenburg area was reclaimed and the shipyard was constructed. This means that the wooden installation was built in one phase and dates from the beginning period of the shipyard which remained in use by the VOC till 1799.

However, some other facts are in contradiction to this interpretation. It seems odd that the surface of the planks appear to be brand new, freshly sawn with no traces of damage or use, no tarspots or nailholes, although the slipway was used for nearly 150 years. Also, there was no refuse underneath the floor. Nor were there any wood chips or lost tools, which one would expect after such a long period of building activities. Most intriguing was the fact that the plank floor is virtually horizontal. Without a tilt the floor lacks the basic principle of a slipway, tersely put into words by Van Yk in his 17th century handbook of Dutch shipbuilding as 'higher at the rear and low at the front...to facilitate the launching of ships' (Yk 1697: 23–24). Nevertheless, proof to sustain the identification as a slipway was found in the clay deposit on the floorplanks. The few finds of ceramic refuse all dated to 1600–1640, the period prior to the construction of the floor. Similar material was found in large quantities on the harbour bed in front of the island and in the subsoil of the island itself. Oostenburg was build up with dredged silt and refuse from the city, dating from the first half of the 17th century. Immediately after its completion the plank floor was covered with clay and silt which was dredged up right in front of the harbour bank, which contained some of the building material of the island itself. This mass of soil was shaped into a slope and probably covered with oak planks that provided the actual working floor of the slipway. A 5° slope can preliminarily be reconstructed from some undisturbed wood chip levels belonging to the overall slope of the terrain next to the slipway. In fact, the recovered floor was not the slipway itself, but the foundation of the slipway slope consisting of a raised soil mass (Fig. 21.13).

Compared with the Hogendijk slipway, the technical solution of the VOC yard offers a remarkable fusion of traditional construction and modern engineering. On one hand the old principle of a raised slope is applied, but on the other hand a new feature is introduced by founding the entire soil mass on a heavy wooden floor. The box-like foundation of the slope prevented the gradual sinking of the slipway and the regular of raising the floor as in the Hogendijk case. The construction of such a large scale installation shows functional building planning, the availability of necessary capital and a scaling up of the shipbuilding facilities in the VOC context. The archaeological research has provided information on the 'modern' aspects of the technical approach and the construction procedure of the VOC slipway. This data illustrates in a broader context the innovative role of the VOC as a shipping and ship producing company and proves the importance of historical and archaeological shipyard research in relation to the development of pre-modern trade and industry.

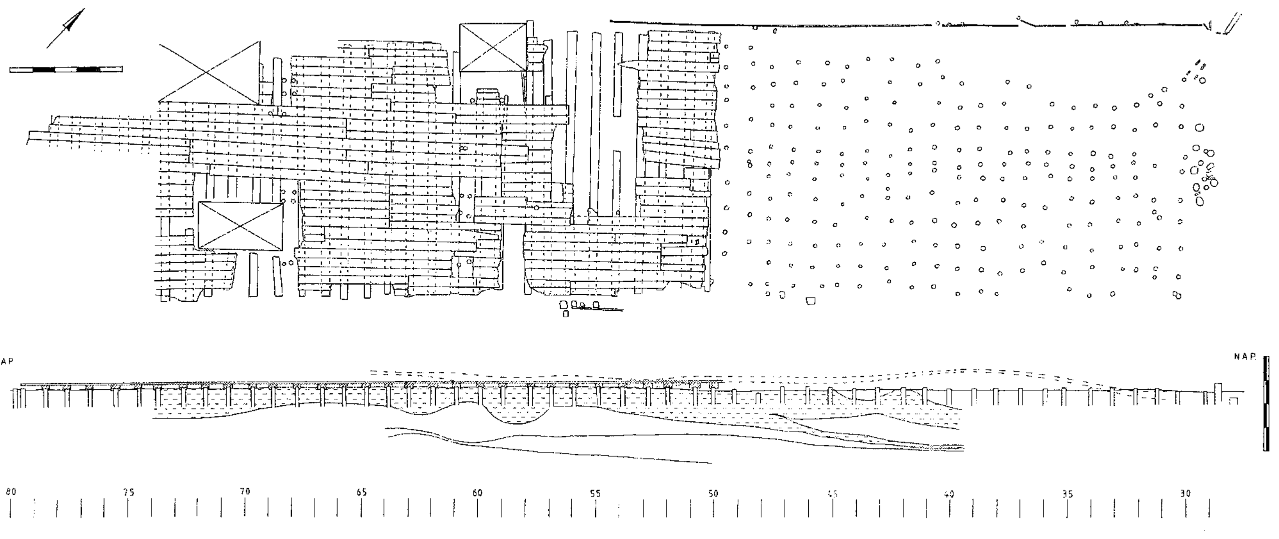

Fig. 21.13. Plan of the remains of the floor and beams with rows of foundation piles in the front section of the slipway. The profile shows a practically horizontal floor and strengthened piles at the front: the dotted line indicates the remains of the clay slope on top of the floor (afdeling Archeologie, Amsterdam).

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22. Moulds, Rising Boards and Bevel Boards. The Wooden Memory of the Shipyard of Le Locum, Lake Geneva

Paul Bloesch

Introduction

The aim of this article is the presentation of the technical archives of a shipyard situated on the French side of Lake Geneva in the hamlet of Le Locum, about four kilometres west of Saint-Gingolph and the Swiss border. It was operating between 1895 and 1938. The vessels built and repaired there were almost exclusively *barques* and *bricks* of the lateen-rigged *Barque du Léman* type (Fig. 22.1). *Barques* and *bricks* looked alike, the only difference being their size: *barques* had a cargo capacity of between 90 and 180 tons, *bricks* of between 30 and 70 tons (Cornaz, 1976: 3). The design and building method used with the *Barque du Léman* is of Mediterranean origin (Cornaz, 1976).

The shipyard of Le Locum was founded in 1895 by the *Compagnie française de construction et réparation de barques du Léman.* Its director was François Jacquier, who had learnt his trade at Saint-Gingolph in the shipyard of Benjamin Derivaz. The new yard of Le Locum existed until 1938 when the time of the *Barque du Léman* was about to be over. After the Great War, it was directed by Louis Jacquier, one of the sons of François (Cornaz, 1976: 98).

What we have just called the technical archives of the shipyard are nothing else but the moulds together with their associated pieces, such as rising boards and bevel boards, which have served to build the individual vessels and which have been kept for documentation and eventually to be used again. With their form, size and marks, together with some additional annotations written on them,

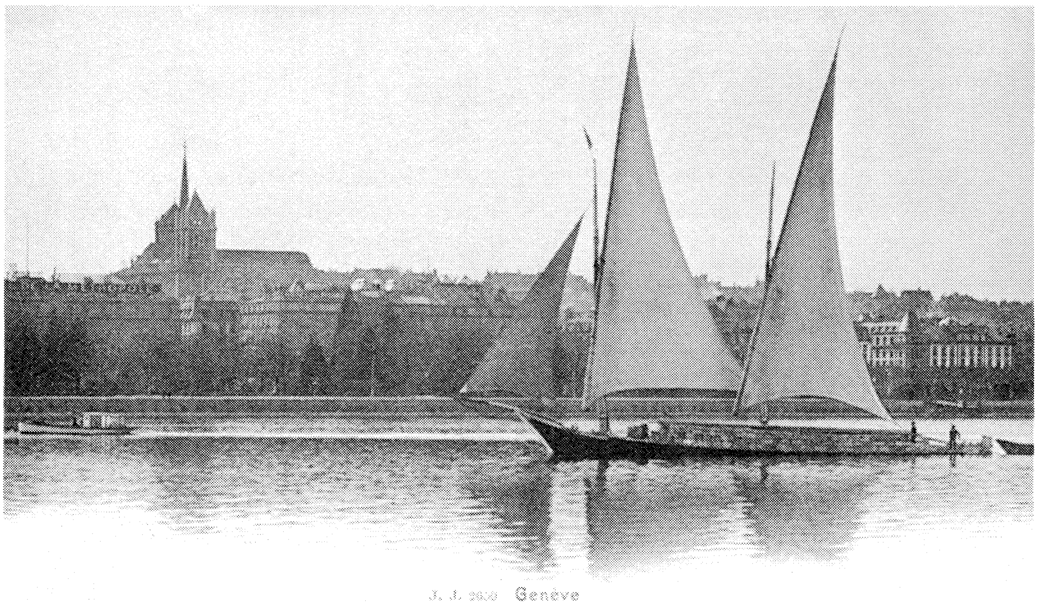

Fig. 22.1. Barque du Léman, ca. *1900 (postcard).*

they constitute a unique and almost complete documentation of the form and size of the vessels for which they have been established: the *Barque du Léman* in its final stage of development. More than fifty objects accumulated during the time of the shipyard's existence: floor moulds, rising boards, bevel boards and futtock moulds. They represent about seventeen vessels, fourteen built at Le Locum and three older ones (Table 22.1–22.2). The fourteen vessels built at Le Locum include one flat-bottomed *cochère* which will not be considered here (Cornaz, 1976: 100).

Louis Jacquier, the last *barque* builder of Le Locum – and of the Lake – lived until 1959 in his house at Saint-Gingolph where he was visited regularly by Gérard Cornaz collecting precious first-hand information about the local *barque* building technique (Cornaz, 1976: 1–2). When Cornaz published his monograph *Les barques du Léman,* he included in its appendices drawings of the outlines of some selected specimens of floor and futtock moulds, the numerical transcriptions of the narrowing and rising scales, and some more specifications he took from the moulds and associated pieces he was shown by Louis Jacquier (Cornaz, 1976: 185–186, 188–190).

After the decease of Louis Jacquier, in 1959, these moulds disappeared. There had even been apprehensions that they might be definitely lost, until, a few years ago, the old house, which still belongs to the Jacquier family, needed its roof to be repaired. As soon as the first rows of tiles were removed and plenty of daylight came into the loft, the moulds could be seen neatly tied up and hanging right under the ridge of the roof where they obviously had been hidden away.

Maurice Jacquier, Douvaine (Haute-Savoie, France), a grandson of Louis, has now taken care of them. Some pieces have been deposited in local museums or given to the proprietors of the last two surviving *barques,* the *Neptune,* at Geneva, and the *Vaudoise,* at Ouchy.

According to Cornaz, twelve *barques* and *bricks* were built in the yard of Le Locum. In addition to them we have to mention a thirteenth unity, the *brick Franco-Russe,* which is attested by its rising board only (see Table 22.2). Most of these vessels were built before the Great War. Table 22.1 gives the years of their construction, their names, length of keel, and cargo capacity in cubic metres of stone.

Description of the moulds and associated objects

In summer 2000, I had the opportunity to record in detail about eighty per cent of the pieces in question, hoping to be able to do the rest in the near future.

The curved shape of the floor and the futtock moulds has been recorded by taking offsets from a straight base line. The measuring of the rising boards did not present any problem, and in the case of the bevelling boards I took to full size tracings on transparent plastic sheets. This work resulted in 1:5 scale drawings. The scale 1:5 has been selected as it proved to be just large enough to allow the detailed representation of the narrowing and rising scales and of the bevel angles scribed on the different pieces.

Year	**Name**	**Keel (metres)**	**Capacity (cubic metres)**
1895	Marguerite-Hélène	16.30	23
1896	Amiral Courbet	19.12	43
1897	Abd-el-Kader	16.45	ca. 28
1899	Franco-Russe	16.90	
1899	Champagne	26.36	120
1901	Andalouse	25.80	ca. 88
1903	Gauloise	20.20	60
1903	Lorraine	25.20	96
1903	Neptune	23.04	ca. 80
1905	Bourgogne	29.20	150
1907	Moselle	16.75	30
1926	Victoire	17.50	35
1931	Violette	15.00	30

After Cornaz, 1976: 100. The years of construction have been taken from the original moulds and boards; they do not all correspond with those given by Cornaz. The data concerning the *Franco-Russe* are those written on its rising board (see Table 2). The keel length of *Amiral Courbet* is that given by Cornaz (1976: 190).

Table 22.1. Barques *and* bricks *built at Le Locum.*

The present state of preservation and recording of the moulds and associated objects coming from the shipyard of Le Locum, is shown in Table 22.2. Vacant cases indicate that the corresponding object has not yet been identified or might have to be considered as definitely lost. In the other cases the first lines are reserved for the actual owner of the piece and, eventually, the depositary (museum). The letters MJ signify Maurice Jacquier, Douvaine, GC: publication by Gérard Cornaz, and Drawing PB means that the piece has been fully recorded and drawn in 1:5 scale by the present author.

From Table 22.2 it appears at the first glance that only two vessels are represented by a complete set of moulds and boards, the *barques Gauloise* and *Lorraine,* both of 1903. Yet the vacant cases in the futtock mould column do not strictly indicate as many missing moulds. One futtock mould could well be used for different vessels of similar size. This might also be the reason for the missing names on the two last futtock moulds.

A special case is that of the floor mould of the *barque Genevoise.* It bears on one side the narrowing marks of the floors going into the fore part of the vessel and on the other side those of the floors aft of the master frames. This mould therefore can not have been used in the building of this *barque;* working moulds always bear the same narrowing scales on both sides. The *Genevoise* was built at Saint-Gingolph in 1891 (Cornaz, 1976: 174). The 'double-sided' mould can only have been copied from the original set of floor moulds, probably by François Jacquier, with a view to keeping it as a model. One of the

Name	Floor mould forward	Floor mould aft	Rising board	Bevel board	Futtock mould
Genevoise [1891]	Maurice Jacquier, Douvaine Drawing PB				
Jeanne d'Arc 1893				MJ Drawing PB	
Vaudaire 1894	MJ Drawing PB	MJ Drawing PB			
Marguerite-Hélène 1895	MJ Musée chablaisien, Thonon GC Drawing PB	MJ Musée chablaisien, Thonon GC Drawing PB		MJ Musée chablaisien, Thonon Drawing PB	
Amiral Courbet 1896	GC	GC	MJ GC Drawing PB	MJ Drawing PB	
Abd-el-Kader 1897	GC	GC	GC		
Franco-Russe 1899			MJ Drawing PB		
Champagne 1899	GC	GC	MJ GC Drawing PB	MJ Drawing PB	
Andalouse 1901	MJ GC Drawing PB	MJ GC Drawing PB	MJ GC Drawing PB		GC
Gauloise 1903	MJ GC Drawing PB	MJ GC Drawing PB	MJ GC Drawing PB	MJ Drawing PB	GC
Lorraine 1903	MJ GC Drawing PB	MJ GC Drawing PB	MJ GC Drawing PB	MJ Drawing PB	MJ Drawing PB
Neptune 1903	Fondation Neptune, Genève GC Drawing PB	Fondation Neptune, Genève GC Drawing PB			
Bourgogne 1905	MJ GC Drawing PB	MJ GC Drawing PB	MJ GC Drawing PB	MJ Drawing PB	
Moselle 1907	GC	GC	MJ GC Drawing PB		
Victoire 1926	Confrérie des Pirates d'Ouchy* Musée du Léman, Nyon GC Drawing PB	Confrérie des Pirates d'Ouchy* Musée du Léman, Nyon GC Drawing PB	GC		GC
Violette 1931	GC	GC	Confrérie des Pirates d'Ouchy Musée du Léman, Nyon GC Drawing PB	MJ Drawing PB	
Unidentified *brick*				MJ Drawing PB	
Unidentified *barque*					MJ Drawing PB
Unidentified *barque*					MJ Drawing PB

* By mistake and contrary to the intention of the donor, the Confrérie des Pirates d'Ouchy did not get the original moulds of their *brick Vaudoise* (ex *Violette*), but those of *Victoire*, which are of about the same size. Both moulds bear the inscription 'Brick Viollette Griond 1931', which obviously has been added only recently in a futile attempt to authenticate the pieces. The word 'Griond' is nonsense; it is the work of a clumsy copyist. Eloy Giroud is the correct name of the owner for whom the *brick Violette* had been built. The inscription on the rising board of *Violette* reads: 'Brick Giroud Violette 1931'. It is nevertheless easy to distinguish the floor moulds of the two *bricks*, the frames of *Victoire* being numbered from M to 14 forward and from M to 16 aft, those of *Violette* from M to 12 both forward and aft (see Cornaz, 1976: 188).

Abbreviations: MJ Maurice Jacquier, Douvaine; GC Published by Cornaz, 1976: 185–186, 188–190; Drawing PB Recorded and drawn in 1:5 scale by Paul Bloesch

Table 22.2. State of preservation and recording of the moulds and associated pieces coming from the shipyard of Le Locum

original moulds, the forward one, is now in the Musée du Léman. It enables us to check the accuracy of the copying, which has been done with an average allowance of less than one millimetre.

Let us now examine one of the complete sets of moulds and associated objects, that of the *Lorraine,* built in 1903. In consists of five objects: two floor moulds, one rising board, one bevel board, and one futtock mould. They are all made of thin boards of fir or spruce wood.

The two floor moulds (Fig. 22.2) are each made in one piece of identical shape. The thickness of mould D (signifying *devant,* or forward), varies from 13 mm at the straight end to 16 mm in the middle and to 13 mm at the curved end. Mould A (*arrière,* or aft), is 12 mm thick at the straight end, 19 mm at the reference line, and 15 mm at the curved end. Mould D bears on both sides the narrowing scale for the pre-determined floors of the fore body, the other (A) bears, again on both sides, the narrowing scale for the after floors. The reference lines (a) serve to accurately position the futtocks at their overlap with the floors, and the points where they touch the outline of the floor at the turn of the bilge, define the breadth of the floor, which is about one sixth of the keel length. The width of the mould at the reference line is that of the finished floor; amidships the moulded dimension of the floor will be more than that of the mould because of the deadrise. Both floor moulds bear several annotations which will be presented later together with those written on the other boards.

The rising board (Fig. 22.3) is 56 cm long, a little less than 24 cm wide and 13 mm thick. Its width is that of the upper surface of the keel. It bears on one side the marks of the floors going into the fore half of the hull (D) and on the other side those of the after half (A).

The bevel board (Fig. 22.4) is a little less than 60 cm long, 12 cm wide and 8 mm thick. Its width is equal to the siding of the frame timbers. As in the case of the rising board, one side is reserved for the marks relative to the frames going into the fore half of the hull (D), the other for those of the after half (A). On both sides the bevels of the futtocks are scribed on the upper half of the surface, those of the floors on the lower half. The last bevel of the after futtock series is that of the fashion piece.

The last of the five objects is the futtock mould (Fig. 22.5). It is made of two pieces scarfed together with a multitude of small nails. Its thickness is 19 mm at the foot, 22 mm at the scarf, and it goes diminishing to 12

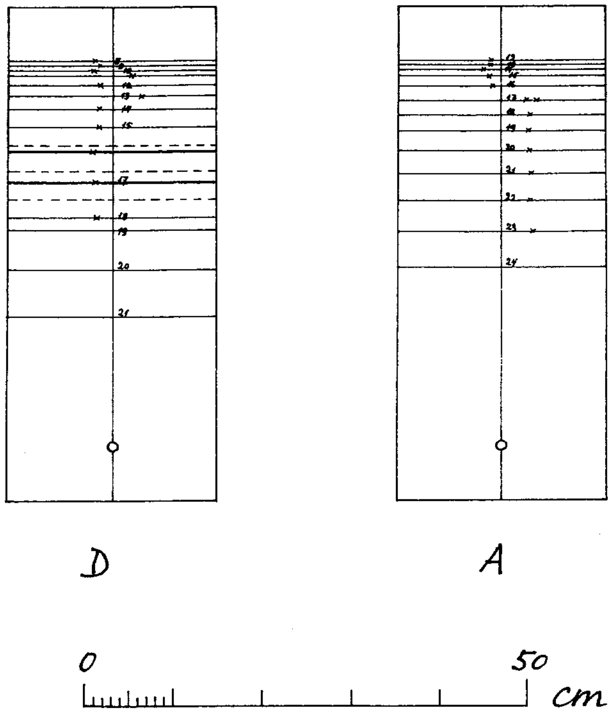

Fig. 22.3. The two sides of the rising board of Lorraine, 1903. D: Forward; A: Aft (drawing: P. Bloesch).

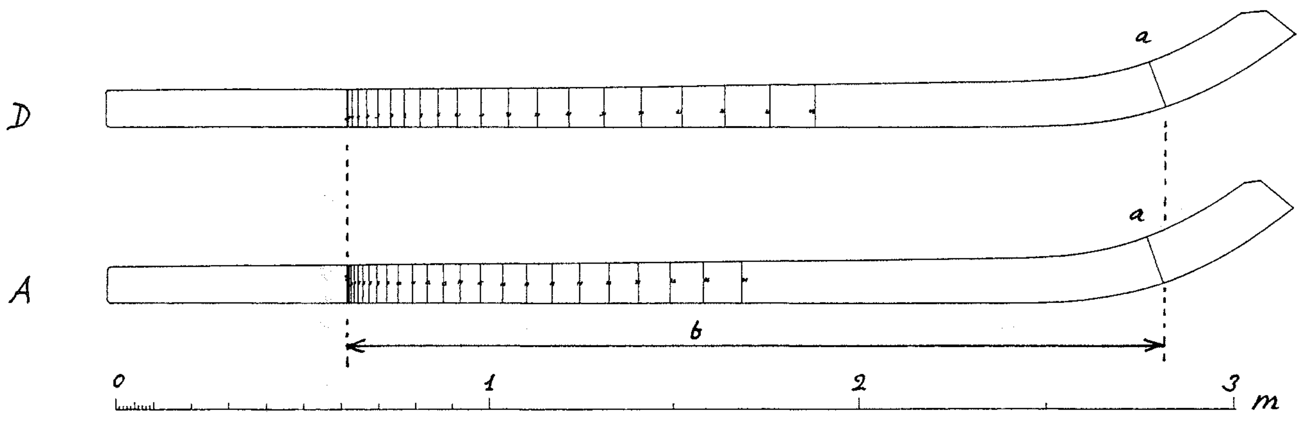

Fig. 22.2. Forward (D) and after (A) floor moulds of Lorraine, 1903. a: Reference line; b: Half-breadth (drawing: P. Bloesch).

mm at the top end. Its width is that of the moulded width of the finished futtock.

The tapering in thickness can be observed in almost all moulds which have been studied; affecting the position of its centre of gravity, it might have been of some importance when handling the pieces in the moulding process.

The annotations written on the different moulds and boards read as follows: '43 1/2 distanse' and '11 mtr. 20 de quil' on the forward floor mould, '14 mtr. de quil' on the after floor mould, and '2 mt. 60 hauteur meure' on the rising board. The total length of the keel is thus 25.20 m, the distance between frames, measured from one moulding edge to the next one (room and space) is 43.5 cm, and the depth in hold near the fore end of the keel (at the bitts to be exact) is 2.60 m. The depth in hold of *barques* was usually measured from the top of the keel to the underside of the deck planking (Cornaz, 1976: 168). Keel length and distance of frames are the basic informations which are recorded in almost every case. Additional information can be as scarce as with *Lorraine* or quite detailed as with *Champagne* of 1899: Here we are informed, besides keel length ('13.08' [+] '13.28' [=] '26.36'; but 'totale de quil 27 mtr.'), and distance of frames ('48 distanse courbe'), about the half breadth of the floor at the master frames ('metres 2 mt. 30 rapor'), the depth in hold as measured at three places, namely at the sternpost ('hauteur piquet 1 mt. 90'), amidships ('hauteur gran portere 2 mt. 25'), and at the bitts ('houteur meure 2 mt. 70'), the length of the wing transom ('bancas 3 mt. 20'), the distance from the stem to the bitts ('de l'a taite meure 6 mt. 80'), and the distance from the stem to the foremast ('de l'a taite trinquet 4 mt. 70').

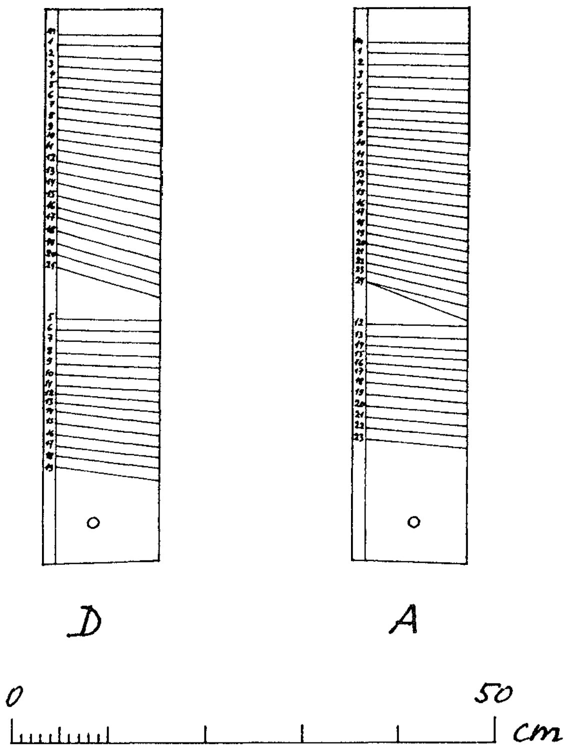

Fig. 22.4. The two sides of the bevel board of Lorraine, 1903. D: Forward; A: Aft (drawing: P. Bloesch).

Short description of the building method

The actual building process began with the laying down of the keel and the erecting of the frames which had been shaped with the help of the moulds and boards we know. These pre-shaped and pre-erected frames represented about 75 per cent of the total number of frames (Cornaz, 1976: 72); in our example of the *Lorraine* they are forty-three out of fifty-eight in all (Fig. 22.6), or 74 per cent. The frames at the ends of the vessel, in the *Lorraine* seven forward and eight aft, had to be shaped later with the aid of ribbands fixed forward between the pre-erected frames and the stem and aft between the pre-erected frames and the fashion pieces. The finished skeleton was then planked in and out, and the deck was laid according to general practice.

It is not necessary here to explain once more the moulding method which John Patrick Sarsfield has called Mediterranean moulding (Sarsfield, 1991). There are nevertheless two points which are probably not super-

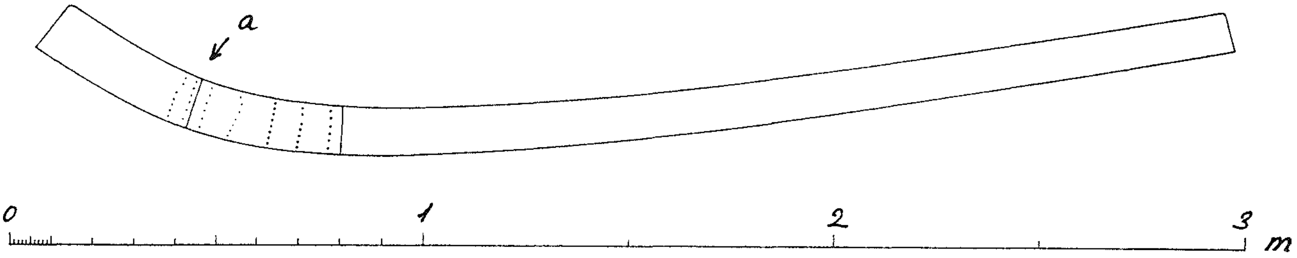

Fig. 22.5. Futtock mould of Lorraine, 1903. a: Reference line (drawing: P. Bloesch).

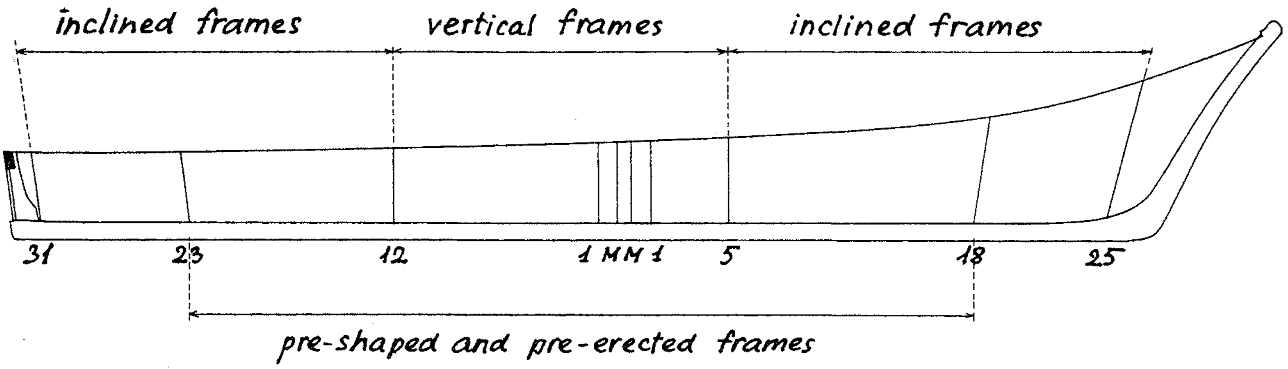

Fig. 22.6. Framing of Lorraine, 1903 (drawing: P. Bloesch).

fluous to repeat and on which I would like to insist: first, all of the pre-erected frames without exception are moulded directly from the moulds and rising boards; there is no distinction between standing frames and filling frames – and, second, their bevels are taken from the bevel board which has been prepared following empirical rules, and not from ribbands. It might be interesting to note that the shipyard of Le Locum was equipped with a water powered saw with an adjustable table for cutting the pieces directly with the bevel given by the bevel board (Cornaz, 1976: 99).

Fig. 22.7 recalls the principles of the moulding process (Cornaz, 1976: 72–73) and helps us to make some remarks:

- the floors of the middle part of the vessel have a constant deadrise of a few centimetres (Fig. 22.7a);
- the rising frames have the middle part of their upper faces cut horizontally, and their lower faces according to a straight line between the heel and the runghead (Fig. 22.7b);
- in assembling the frames, which is done before erecting them on the keel, the futtocks are fixed to the floors under a constant angle in the middle and after frames (Fig. 22.7d), but in the forward frames, they are 'opening' gradually to give additional width to the upper part of the sides (Fig. 22.7c). This opening of the upper ends of the futtocks, about 5 to 8 cm on each side, is called *ébrasure* (or *embrasure*) on Lake Geneva.[1] It is the equivalent of the Venetian *ramo* (Bellabarba, 1993: 281).

As we have seen in Fig. 22.6, only the frames of the central part of the hull are set vertically on the keel. From number 6 forward and from number 13 aft the frames are set inclining at regularly increasing angles given by the bevel board. Fig. 22.8 illustrates the effect this inclination of the frames has on the load waterline. Point A on the frame in its upright position is carried forward to A', thus enlarging the surface circumscribed by the load waterline. In the fore half of the hull this gradual widening of its sides is further increased by the *ébrasure*. It creates additional buoyancy at and above the waterline forward and aft, thus improving the stability of the vessel as well as its sailing performance.

The inclination of the frames achieving the correction of the beam of the vessel has a striking parallel in the design and building method used at Bahia, Brasil (Sarsfield, 1988). A similar pattern of framing can be observed in the 16th century Red Bay vessel. In the after half of the skeleton the inclination of the frames begins well within the group of fourteen central frames which, their floors and first futtocks being joined by dovetail mortices, seem to have been pre-shaped and pre-erected (Grenier *et al.*, 1994: 138, fig. 1). Just before the presumed master frame the situation is less clear, but further forward the inclination of the frames is unmistakable. These two examples are the only parallels to the Lake Geneva practice known to me up to now. Lavanha mentions inclined frames in his *Livro primeiro* (Barata, 1965: 292), but they are to be placed near the stem and the sternpost where they cannot have any influence on the correction of the beam. According to Lavanha their inclination serves only to regularly fill in the space between the last vertical frames forward and the stem, and between the last vertical frames aft and the fashion pieces.[2]

Conclusions

These moulds and their associated objects are a most valuable source of information about the ship design and construction method used on Lake Geneva. This technology being part of the Mediterranean tradition, the interest of our objects is much more than local. They merit being studied most carefully and they will be able to throw light on more general questions. All their elements of information: form, narrowing and rising scales, bevel angles, can be taken off and analysed with the same degree of accuracy as was used in building the actual ships.

These moulds and boards are related to the real building process on the shipyard rather than to the rules and theories

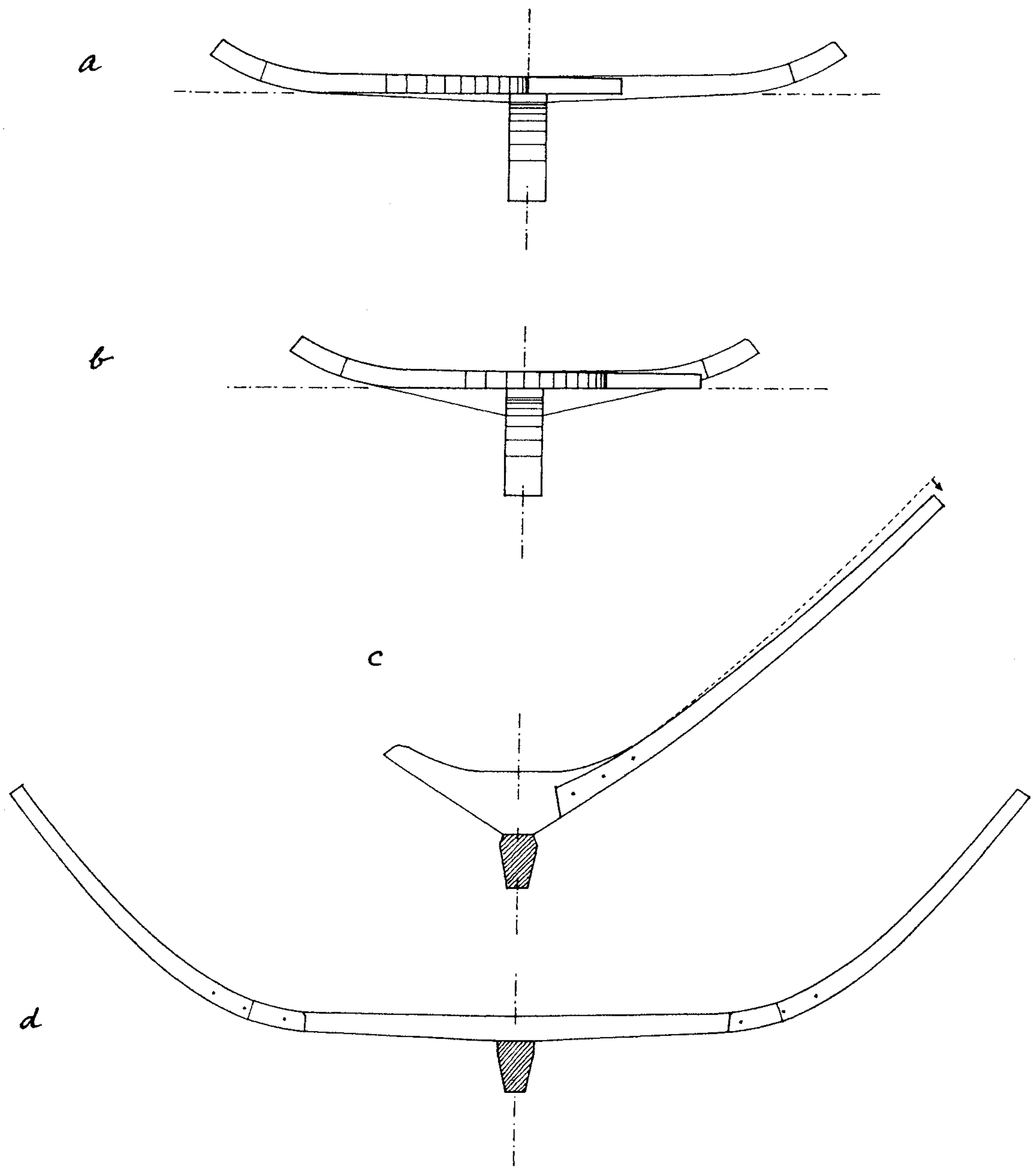

Fig. 22.7. Moulding and erecting the frames. a: Midship floors; b: Rising floors; c: 'Opening' of the forward futtocks; d: Completed frame (drawing: P. Bloesch).

of technical treatises. Many of them do not only hand down to the modern student the specifications of the original design of the future vessel, but they also show traces of modifications made during the building process (Fig. 22.3 D).

Finally it should be noted that on Lake Geneva the recording of shipbuilding specifications had not only been done by moulds and their associated objects, but also by writing. The Musée du Léman at Nyon keeps a 19th century manuscript which had been hidden in a private collection until less than ten years ago. Compiled by several members of the shipwright family Derivaz of Saint-Gingolph, it covers the period between 1813 and 1863 and contains thirty-one specifications of *barques, bricks* and flat-bottomed vessels.[3] The early dates of the first Derivaz specifications, and the fact that François Jacquier had learnt his trade on the Derivaz shipyard, enable us to closely follow up the evolution of a very old design and construction method during the last century of its existence.

Acknowledgements

I am most obliged to M. Maurice Jacquier, Douvaine, for allowing me to study and to publish the moulds and

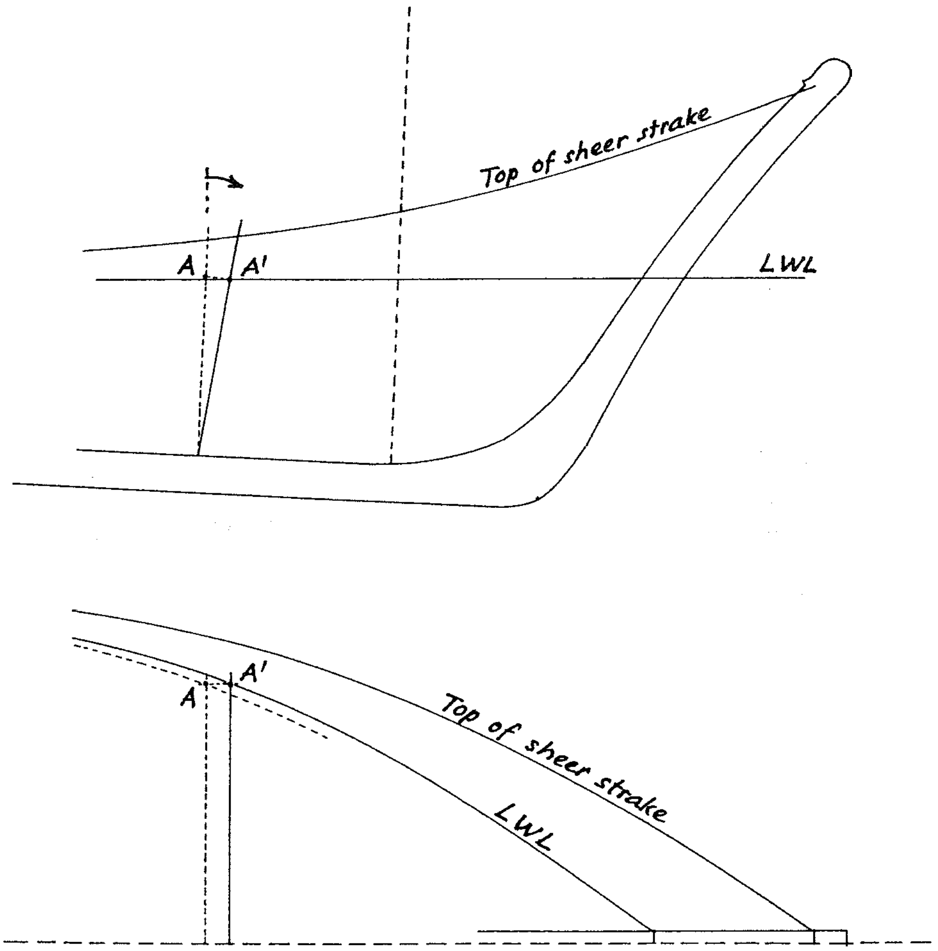

Fig. 22.8. The effect of inclined frames (drawing: P. Bloesch).

associated pieces in his possession as well as for providing excellent working conditions. Similarly, thanks are owed to M. Jacques Mouron, Geneva, to M. Machiel Post, *patron* of the *barque Neptune*, to the *Confrérie des pirates d'Ouchy* and to M. Alain Kespy, *premier patron* of the *brick Vaudoise*, to Mme Carinne Bertola, director, and to the staff of the Musée du Léman, Nyon, and to M. Gilles Bondaz, Thonon.

Notes

[1] Nyon, Musée du Léman, Fonds Louis-E. Favre, Livre de chantier Derivaz, fol. 10r, 13v, 26v.

[2] The same or a similar arrangement of frames seems to be present in the galley *Kadirga* in the Naval Museum in Istanbul (Arcak , in press).

[3] Nyon, Musée du Léman, Fonds Louis-E. Favre, Livre de chantier Derivaz.

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23. The Tyrrell's Boatyard of Arklow, County Wicklow, Ireland

Darina Tully

Introduction

The Town of Arklow, and the Tyrrell family, have had a long history of seafaring, ship owning and boatbuilding. Arklow is a small town on the East Coast of Ireland, built on the estuary of the River Avoca, surrounded by woodlands and near the great oak forests of Coolattin. It was marked as *Manapia* on Ptolemy's map of 150 AD. Having been an Early Christian Settlement, Viking Town and Norman Port, Arklow is strategically placed for trade with the Welsh and Bristol Channel ports.

In 1663 William Petty had one of his revolutionary Catamarans built in Arklow. In the early years most of the boatbuilding was carried out in the open on the north side of the river where there were numerous small huts and wood was worked with pit saws. The launching of boats was by an old method called 'docking out', which meant cutting a channel from the high water mark to the building berth.

In the mid 19th Century, the antiquarian De Noyer made a number of sketches of the Arklow fishery and boats. In 1880, with a population of only 5.400, Arklow was home port to 80 trading vessels and 160 fishing boats (Forde, 1981: 9–10). Between 1800 and 1940 Arklow families owned over 250 sailing merchant vessels (Rees, Charlton, 1986). Ships were financed by the 64th share system, and middle and working class families bought shares in ships. Because so many men were involved in seafaring, the town was quite matriarchal, with most of the businesses and finance handled by the women. A local form of financing evolved where goods and services were provided on a credit basis, and accounts were settled when ships reached their destinations. During World War Two, when Ireland was desperately short of tonnage, Arklow maintained a fleet of 14 ageing schooners, which brought in vital supplies from Lisbon and the Welsh Ports.

The Tyrrell's Boatyard

The young John Tyrrell served a shipwright apprenticeship locally in Arklow. He went on to work in the naval dockyard at Devonport, England. Returning to Ireland in 1864 he opened his own yard on the site of a mining company mill on the south side of the Avoca Estuary. The firm was called 'John Tyrrell and Son'. In the 19th Century they built schooners, coasting vessels, and fishing boats, including the local indigenous design *Arklow Yawls.* In 1904 the yard designed and built the motor yacht *Express,* which led to the development of *The Ovoca* in 1905, the first purpose built motor fishing boat in the British Isles. By the 1914/18 war the yard was busy under Michael Tyrrell, building for the war effort.

In 1921 *The Invermore* was built in the yard. Like her sister ship, *The JT and S,* built two years earlier, she was a compromise between sail and motor design. They were the last merchant schooners to be built in the British Isles (Greenhill, 1988: 259). They were very efficient boats, and worked up to the 1960's.

The Survey

In 1996 the author, while researching the local indigenous boats on the East Coast of Ireland, learned of the imminent demolition of the Tyrrell boatyard. A rescue survey was arranged with some colleagues, Criostoir Mac Carthaigh (Department of Irish Folklore) and Tom Moran (Archaeologist and Surveyor). As the actual site and buildings are represented on the local ordnance Survey map, the survey concentrated on the interior layout, and the process and arrangements by which boatbuilding took place.

It was decided to create a record of the site using digital video of archive quality, and stills photography. The team was fortunate, in that the last owner, Michael Tyrrell, and local historian Mr Jim Rees, agreed to be interviewed and filmed in the boatyard.

The main central building was around 50 m long by 12 m high facing on to the River. There were a number of auxiliary buildings with some of the equipment still extant.

For each area the processes that took place were explained and recorded. Recording started in the drawing office, located to the front of the building. A two level annex ran the length of the main building. The upper floor was used for lofting and pattern making. The ground floor had a mast table running the full length of the building, used for working spars and splicing masts. The main hall had a series of tracks and hoists for moving boats around the interior of the building. A large timber storage area and covered sawmill was located to the left of the main building. A boiler house and chimney had been located in the right hand corner of the site. A large steel pipe ran from this through the main hall, which was used for steaming timbers. The doors to the front of the building were made by the shipwrights, and were of double diagonal planked construction. They could be opened at a number of different levels, to permit components and boats of different sizes to be passed through.

Boats were fitted out as much as possible before being launched. In the early years larger boats were launched broadside, slid over baulks of timber or parbuckled into the river. Later a series of tracks were fitted within the covered yard and across the road, extending down the slipway. The yard processed most of the timber it needed, working closely with the local sawmills that were mainly commissioned to cut and draw the timber to the yard. Sometimes the shipwrights would walk the local forests, choosing specific trees for particular boats. Hardwoods were imported directly into the harbour and discharged close to the yard. In the early 19th Century there had been a ropeworks in the town, and over 1.000 women and children were employed in the local hemp industry. Women were also involved in net making. There had also been sail lofts, but in later years much of the rigging was brought in from the industrial cites in England. Most of the ironwork was done either in the yard or locally.

It was necessary to have a number of boats at different stages of production in order to keep up to 50 shipwrights and mill workers constantly employed. Under Jack Tyrrell, workmanship at the yard was to a very high standard. Careful loft work and good bandsawing, where timber was cut precisely, with attention to accurate frame bevelling, meant almost no hand trimming of frames was required, and after construction, hulls needed very little fairing.

The legacy

Jack Tyrrell took over the yard in 1948 and in the next 50 years built over 150 wooden boats, designing an additional 100 boats that were built elsewhere. In 1959 *Gypsy Moth 111* was built in the Yard. It went on to win the single handed Transatlantic Race in 1960, and again in 1962. Jack introduced tank testing in the yard, and worked closely with the RNLI designing and building lifeboats. He designed the *Clyde Class,* at the time the largest off shore cruising lifeboat class. The yard became well known for pilot boats, *'Jack Tyrrell'* yachts, and motor sailors. Demands on space saw the boatbuilding expanded into a second yard for a time. In the 1970's the firm was taken over by Jacks two sons, Michael and James. Jack, although retired, was commissioned to design a new national sail training vessel for Ireland. The design was based on a family boat, which Jack had served on as a young boy 65 years earlier. In 1981 the result of his labours, the 28 m Brigantine *Asgard 11* was launched. *Asgard 11* was not a replica or an experiment, but the result of a continuity of tradition kept alive by the Tyrrell family and the maritime community in Arklow.

In the early 1990's the yard closed, even though there was still a demand for the Tyrrell boats. It was a case of the waterfront site having become more valuable than the business generated by the boat yard, a problem which has sealed the fate of many shipyards, discussed in a paper by Stammers (1999).

Arklow is still a major ship owning town, as Arklow families trading as Arklow Shipping Ltd, own most of the tonnage under the Irish Flag. Another branch of the Tyrrell Family runs a successful steel shipyard on the north bank of the river. The synchro lift, introduced by the Tyrrells in the inner Harbour, is still in operation. A small amount of wooden shipbuilding and repair is still carried out locally, but with the closing of ' John Tyrrell and Son' it was the end of the era of the large wooden boat yards in Ireland.

Acknowledgements

The Author would like to thank Mr Michael Tyrrell for the family history and information on the boatyard, Mr Jim Rees for the background maritime history of Arklow, and Arklow Maritime Museum for archive material.

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24. Tracing Ship Traffic without Ships – Alternative Methods of Finding Evidence for Pre- and Early Historical Inland Water Transport

Ulrike Teigelake

The studies presented here are part of a doctorate thesis at the universities of Kiel and Stockholm, investigating the development of inland water communication in Northern Germany between Iron Age and migration period.[1]

While for more southerly areas of Germany and its neighbouring countries, prehistoric and early historical inland water communication has been subject of various investigations, often standing in a context with the Hallstatt and Latène culture (for example Ellmers, 1969; 1989; Pauli, 1993; Salac, 1998), for the Northern part of Germany this topic has so far been studied very little.

The area of investigation is the Northern German plain, between the middle German lowlands and the coasts of North Sea and Baltic, including a part of the Jutland peninsula. The time frame ranges from Preroman Iron Age till Migration period.

To learn about organisation and development of inland water transport and communication, one has to combine several different sources, such as archaeological, historical and geological ones. The archaeological sources again fall into different groups, as shown in Table 24.1.

Because the number of shipwreck finds or of identified harbours in or near inland water ways is usually small, in this paper I will concentrate on what I call "secondary

	Frequency	**Value for the study of inland water communication**	**Important aspects**
- Primary evidence -			
Shipwrecks	Rare	– clear indication of ship traffic – little information about organisation	
Iconographical evidence	Rather rare	– possible information about cargo, propulsion etc.	
Harbours etc.	Rarely identified	– clear indication of ship traffic – possible information about key points in the transport system or other means of organisation	
- Secondary evidence -			
Import and find categories characterised by a large size, heavy weight, fragile constitution etc., found near waterways	Relatively frequent	– possible information about transported goods – possible information about transport key points, places of reloading etc.	– selecting of appropriate find categories – source critical analysis of find distribution – considering of possible transport alternatives
Traces of conspicuous wealth or power, found near waterways	Relatively frequent	– possible information about control points of trade and communication	– considering of possible alternatives of maintaining wealth or power
Natural communication lines in the landscape	Relatively frequent	– possible information about transport or communication routes	

Table 24.1. Potential of different source categories for the study of inland water communication

evidence", characteristic finds which by their distribution indicate a possible transport or communication on inland waters. While these finds can give important clues for the organisation of the transport, they require a much more careful handling than the primary evidence.

An important tool for this investigation are distribution maps. However, one has to be aware that distribution maps can never mirror the original picture of a find distribution. Because they are biased by varying conditions of archaeological survey, the information drawn from them has to be combined with other archaeological, geological and historical facts. In our case, a concentration of finds near a stream might be caused by the fertility of river valleys, making them good settling areas. So it depends on other factors, whether this find concentration can be interpreted as a normal settlement distribution or as a hint for water transport. It is therefore of high importance to use only carefully chosen finds or find categories as evidence for the study of inland water transport, as well as to view these special finds or find categories on the background of the general find distribution.

Keywords in our investigation are communication, exchange in general and trade specifically.

How can we trace these in the archaeological record? Clues can be given by the study of natural communication lines in the landscape or natural conditions for landing places, by traces of raw material in original or worked shape or of other specific items that could have been transported in some way, and especially of imported goods.

To define the find categories that might function as indicators of a transport on the water, we have to ask ourselves: What could be the reason to transport a specific cargo on the water instead of over land?

It seems obvious that a large size or weight is easier to transport aboard a boat or ship, offering space and an easy way to be moved along, than on a carriage or on the back of oxen, mules etc. or even to be carried by man.

As items of large size we can imagine: large metal or ceramic vessels, newly cut wood, large stone pieces. Items of large weight might be: loose or bulky goods like iron, grain, salt etc., rotary querns or other things made of stone, or building material in general. Further, small items can be so fragile, that they are packed together in a larger box or something similar. They would have to be transported carefully, in order to prevent them from breaking, for which case a transport on the water might have been appropriate, too. If this was the case, one might expect a somewhat concentrated find distribution of the above named items near their presumed transport ways, the inland waters and the connecting land routes. However, a reasonable investigation is only possible on the background of the general find distribution. If the latter is widespread, while the chosen find categories show the described concentration, this might point towards a transport on the water.

On this presupposition, finds or find categories and especially import finds which stand for a large size, a high weight, being fragile, or loose or bulky goods, as well as those connected to a conspicuous wealth or power, are being studied concerning their concentration near waterways. Also, apart from the general find distribution in the same area, the geological changes in the course of the waterways as well as natural communication lines in the landscape are taken into consideration.

Since trade, understood in its prehistoric sense to simply mean the transfer of goods (Torrence, 1996: 719), is probably the main motivation for the transport of the above described goods, information about the organisation of the same is an important source for our study.

From the Roman Empire, to which the history and development of the Germanic people is closely connected, a considerable amount of information about trade and transport is available. This information can partly be used directly since there is both written and archaeological evidence for long distance trade from the Roman empire to Northern Germany and Scandinavia, partly conclusions can be drawn concerning general transport conditions, given by the nature of the transported goods and the landscape. Some scholars deny a regular trade between the inhabitants of Northern Germany and the Roman Empire, interpreting the Roman high value goods found there mainly as results of plundering, tribute or gifts (Erdrich, 1995). Jürgen Kunow draws the following picture (Kunow, 1983) for long distance trade in or with the Roman empire.

Usually the Roman merchant, the *negotiator*, specialised in one or a few goods such as oil, wine, ceramics, bronze vessels or the like. In the first stage he received his goods from the Roman production centres and brought them to the big towns by the rivers Rhine or Danube within the Roman empire. Here they were reloaded on ships or land vehicles and taken over by the local merchants. They brought the goods to the markets outside the Roman boarders, from where they were either purchased directly or possibly came to the hands of a Germanic merchandiser before they reached their final owner. Such market places, especially by the Baltic Sea coast, are mentioned by the Roman historian Plinius (XXXVII, 3) in his *Naturalis Historia.* The basis of the trade was usually the exchange of one good for another, but from the second century onwards there are beginnings of monetary exchange. Items of exchange from German side are described in written sources as for example amber, furs or slaves, further on the blond hair of the German woman was a popular thing amongst Roman women, and also goose feathers, soap and dying colour is named.

The means of transport were changing, according to the circumstances, but the cheapest and most effective way was the transport on the water way. This is clearly shown by the price edict of Diokletian, a law to fix the prices for trading goods and services, created in 3rd century AD Roman Empire (Lauffer, 1971). From this source Jürgen Kunow calculated the relation between land transport, inland water transport and sea transport (Kunow, 1983: 53–54). The result shows that the costs of land transport are more than ten times higher than for inland water transport, while sea transport was even more than 60 times cheaper than land transport (Table 24.2).

If this was the case in the Roman empire with its well built streets, it must have been even more so in the areas outside of the Roman borders.

Pictorial evidence for a transport on the river we have from a considerable number of picture stones from Roman or Roman provincial areas. One example is the Pillar of Igel, a grave monument from a place near the German town of Trier by the river Mosel, showing scenes from the live and business of a Gallo-Roman family involved in the textile trade. On one of them we see a large bundle, possibly of textiles, being transported on a towed boat (Fig. 24.1).

The grave relief from Cabrière d'Aigures/ Southern France shows a boat with several barrels, being towed by (originally) three men (Fig. 24.2).

Models

In contrast to for example the Roman Empire, our knowledge about trade and communication in pre- and early historical Northern Germany is very limited. Therefore models of typical phenomena in landscape and archaeological record have been developed, connecting the above described considerations to known cases from reference areas like the area of the West Hallstatt culture (Model 1) (Pauli, 1993), the Bohemian Latène Culture (Model 2) (Salač, 1998), or pre and early industrial iron production in Sweden's Bergslagen district (Model 3) (Cederlund, 2000), to name just a few (Table 24.3).

	Cargo capacity (in cwt)	**Distance per day (in km)**	**Transport costs**
Land transport	5 – 6	18 – 20	62.5
River transport	60 – 140	30 – 40	5.9
Sea transport	600 – 2000	45 – 65	1.0

Table 24.2. The different ways of transport and their costs, with river transport and land transport as multiples of sea transport (after Kunow, 1983: 53–54).

To show an example, I will give a short description of the situation described by Pauli (1993) for the Western Hallstatt area between the middle of the 8th and the 3rd centuries BC, illustrating Model one (Fig. 24.3).

The chieftain settlements of the Hallstatt period (*ca.*

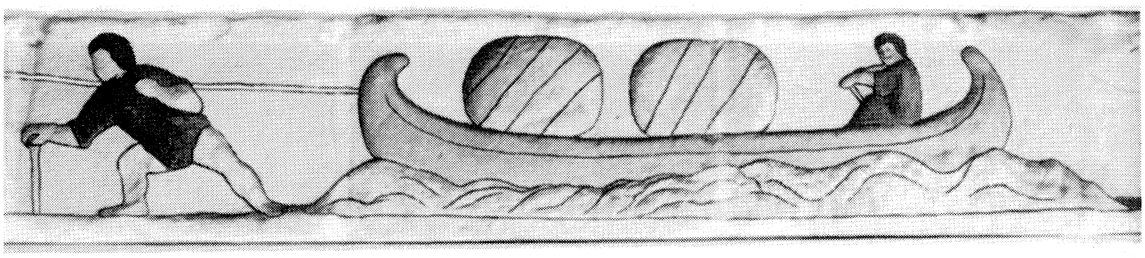

Fig. 24.1. Relief from the Pillar of Igel (after Ellmers, 1969, taf. 18.1).

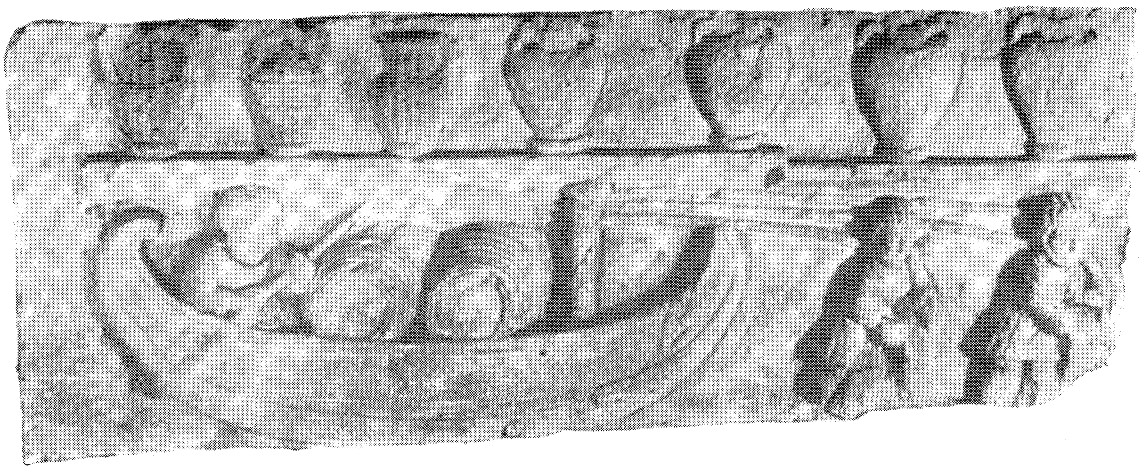

Fig.24.2. Relief from Cabrière d'Aigures (after Espérandieu, 1925, no. 6699).

Model	Criterion	Possible Conclusion
Model 1	Conspicuous wealth or fortifications near navigationable rivers or at transitions from land to water routes	Control of inland water or combined land-water communication lines
Model 2	Settlements near rivers, despite of unfertile land or other bad settling conditions	Role in the organisation of inland water transport
Model 3	Exploiting, working and use of raw material near rivers	Use of waterways in exploiting and production
Model 4	Places near river deltas with evidence for the exchange of goods both inland and overseas	Transition from inland water to sea transport
Model 5	Concentration of far distance import near rivers	Far distance trade on inland water routes

Table 24.3. Models of possible traces in the archaeological record left by inland water transport

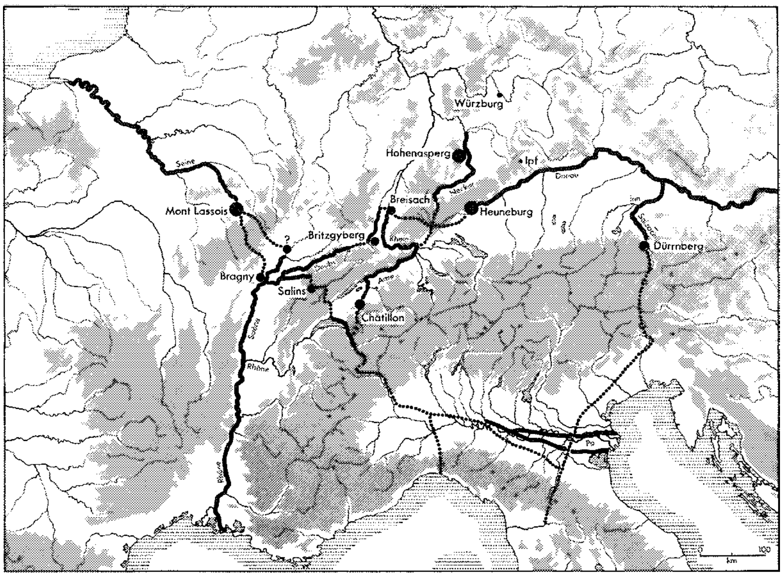

Fig. 24.3. Main communication routes from the South to Middle Europe during Hallstatt D3. ___ Water route .... Land route (after Pauli, 1993, Fig. 42).

700 – 450 BC) are usually defined by Mediterranean import like for example pottery from Athens as well as clusters of rich graves in their neighbourhood. Pauli, in the context of a Hallstatt period settlement on the Münsterberg of Breisach by the upper Rhine in Germany, studied trade routes between Greece via its colony Massalia and the area of the Hallstatt culture. Out of the eleven chiefly settlements seven are standing out because of their location by a navigable river. According to the geological conditions it was not the need for drinking water, but rather the position in the communication system that caused the people to choose this location. Such a position can often be found where land and water ways meet. This could be either a crossing of a land route over a water, or a reloading place from land vessel to ship or vice versa. For both alternatives control of the place would be of economical and probably political value.

The settlements in question, from the Mont Lassois in central France to the Heuneburg by the upper Danube, are all situated by European watersheds, and at such a place, where a transition from land way to water way would have been possible, efficient and easy to control. Based on the fact that all these places show conspicuous wealth, for example in the form of Mediterranean import, Pauli concludes that it should be possible to trace also other, less well known places of transition from land to water transport because of their wealth in the archaeological record.

Evidence

If we apply the above described criteria to the area of Northern Germany, a considerable range of cases to fit one of the models can be found. To give a short overview, one from each period is presented in the following. For the given areas and time periods the general find distribution has been analysed. If not mentioned otherwise, it is a rather widespread distribution without any obvious concentration on large rivers.

A. PREROMAN IRON AGE

In the preroman Iron Age the distribution of beaten bronze vessels show an obvious concentration near rivers, this is especially the case for the area of the rivers Weser, Odra and Rhine (Fig. 24.4).

This concentration of status goods could indicate the control position of their finding places, according to model one, as well as far distance trade in general as described in model five.

B. ROMAN IRON AGE

From the Roman Iron Age we have an example of heavy items possibly being transported on the river. This is the distribution of Basalt Lava rotary querns from middle German quarries in Niedersachsen (Fig. 24.5). Since the quarries in the Eifel mountains are located not far from the river Rhine, the find location of their products near the North Sea coast and the rivers running into it makes it seem likely that the querns have been transported along the Rhine to the North Sea and from there into the river mouths, according to model three.

C. MIGRATION PERIOD

For the Migration period we might have a look at the distribution of coin finds (Fig. 24.6). Their concentration near rivers might be evidence for (far distance?) trade taking place near rivers, as described in model five.

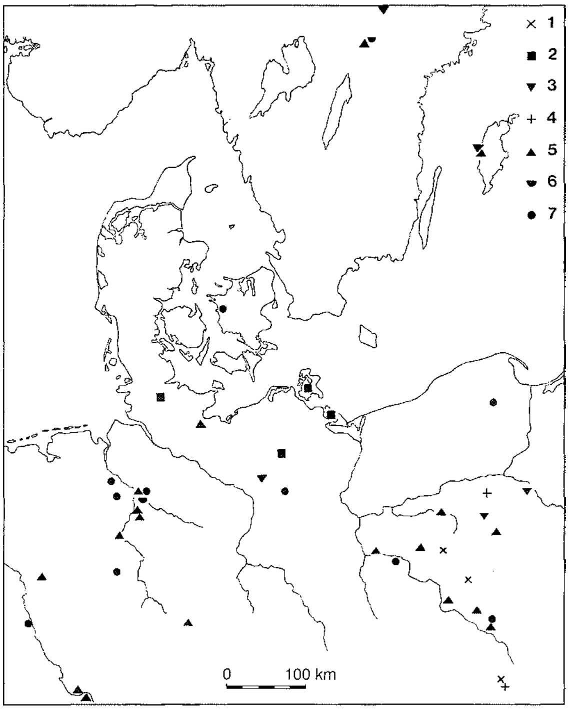

Fig. 24.4. Geographical distribution of beaten bronze vessels of the Hallstatt period. 1: Amphorae. 2: Jugs. 3: Cups. 4: Ladles. 5: Ribbed buckets. 6: Cauldrons. 7: Situlae (after Jensen, 1997, fig. 33).

This short range of examples illustrates a tendency that can be observed in each period under investigation, showing evidence for items possibly being transported on inland water routes. At the same time the general settlement areas are usually widespread, so that the described phenomenon can not be seen as part of the general find distribution.

An exception is the north-western part of Germany, the area of Niedersachsen, where the general settlement distribution shows in fact a concentration near rivers, especially in the Roman Iron Age. But that intriguing situation requires a detailed investigation of its own which can not be undertaken in this frame.

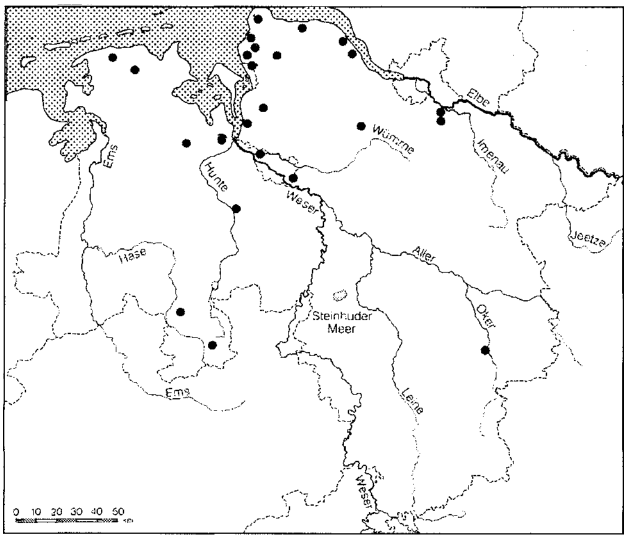

Fig. 24.5. Basalt Lava rotary querns from Niedermendig/ Eifel in Niedersachsen (after Erdrich, 1995, fig. 6).

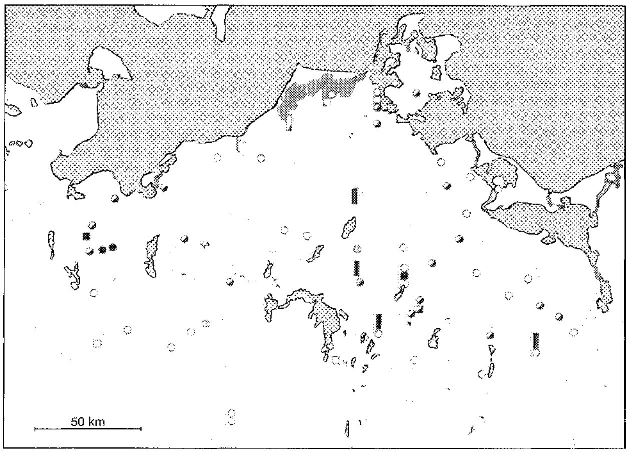

Fig. 24.6. Coin finds of later Roman Iron Age and Migration Period (after Schach-Dörges, 1970, map 11).

Conclusions

I would like to conclude by emphasizing that the method presented here is on the one hand only based on likelyhood, not on certainty, but on the other hand it is only one of several different approaches to investigate the role of inland water transport in a given area. So, in combination with other sources and techniques, it will hopefully help to gain a clearer picture of the organization and development of inland water transport in pre- and early historic Northern Germany.

Notes

[1] To help gaining knowledge about inland waterborne transport through cooperation with scholars of related topics in other regions, first steps have been made to establish a research network in the field of inland water transport. So far mainly colleagues from countries around the Baltic Sea are involved, but we are hoping to extend this network into the whole of Europe and, basically, as far as possible.

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25. Thoughts on the Typology of Stone Age Boat Petroglyphs from the White Sea and Lake Onega, Russia

Maik-Jens Springmann

Introduction

Rock carvings are a valuable source of information on how ancient peoples used boats, and what type of boats. Some of the best-known petroglyphs in eastern Europe are to be found in two particular areas in Karelia on Lake Onega (Oneshki Osero) at the mouth of the Vodla River; and on the White Sea (Beloye More), where some 1300 petroglyphs have already been investigated.

Owing perhaps to the former political system, these pictures have so far received little attention in the west. This is probably just the right opportunity to introduce to these interesting rock carvings, some of which could be found in the Hermitage museum in Saint Petersburg.

These pictures are significant in several respects, in particular they may throw light on the ethnological roots and way of life of the Fenno-Ugrian population. Rock carvings connected with this population have been found in northern Scandinavia, Finland and Russia.

Geographical context

The rock carvings of the White Sea ("Vienanmeri" in Finnish) are located at the mouth of the Vyg River, or Uikujoki.

So far 24 petroglyph sites have been investigated south of where the Vodla River goes into Lake Onega, and I shall present two of the boat pictures from those sites here.

The Onega rock carvings, which have recently been published by Poikalainen, are to be found in two main areas – the Vodla region and the Besov Nos region.[1] These two areas are 13 km away from one another and, up till now, no petroglyphs have been found between the two.

The White Sea petroglyphs are situated on the mouth of the River Vyg which is the third longest river in Karelia and part of the White Sea-Baltic channel. Some 9 km north of the village of Wygostrow begins the river's 2–3 km wide estuary, in a landscape which has changed greatly since the completion of the hydroelectric power station.

The inspiration for these pictures was closely linked with the shape of the coast line of Lake Onega where so-called capes project into the lake.

All the rock carvings are situated close to the waterline of the lake on small islands or at the tips of these capes and caplets which are separated from one another by sandy bays. Some of the pictures (so far 10 have been investigated) were found on loose boulders at the bottom of the lake. These underwater investigations began in the early 1970s und were organised by Sawatejev (Sawatejev, 1984: 37).

Dating

Dating these rock carvings is still very complicated. It is nonetheless helpful to use natural science's account of the land rising after the last glacial period, which is generally used in the dating of rock pictures. Archaeologists have tried to date the Lake Onega Karelia carvings in comparison with the rock art of neighbouring regions, ancient settlements found close to the carvings, and especially pottery found there. The microerosion of bedrock crystals and the relative chronology of the elements of compound petroglyphs, groups and sites within the rock art territory have also been taken into account.

Assuming geomorphological studies of the transgression are correct, we can more easily date the time when ancient people stopped making stone carvings than when they began (Poikalainen, 1998: 38).

The aenolithic transgression around 1850 BC was responsible for the pictures being flooded. Taking into account the recent investigations, we can assume that the water level at the time the rock carvings were carried out, was the same as it is today.

Following the process of land rising that came after the last post-glacial period around 4500–4000 BC, the water level stood on the base of the *demon* that is assumed to be the oldest figure of the Onega complex. Most scholars therefore favour the predecessors of the Balto-Finnic people, the so-called Pit-Comb ceramic tribes, as the creators of these stone pictures, although the pictures could be much older.

The boats

Most of the pictures show quite realistic hunting scenarios or hunting-related scenes. At the time when the tundra became more heavily wooded, the inhabitants followed migrating animal herds, especially elk and reindeer, in order to store thousands of kilos of meat for the hard winter period.

In most hunting scenarios we see boats, or assume boats to be depicted (Fig. 25.1). There are more than 30 such pictures in the Lake Onega area and over 500 in the White Sea complex. These pictures are interesting both for their own sake and in their interpretation.

I believe we see three types of boat here, but we must always bear in mind possible damage to the petroglyphs and the free imagination of the person who made them.

Comparison with other European boat engravings

Stone Age boat depictions are already known in Europe. We know "box-shape" boats with high sides (from Bardal in Norway) and narrow boats (from Evenhus in Norway) which look like Egyptian papyrus boats. Boat pictures from the Stone Age have also been found at Hammer and Roday in Norway. The best-known Stone Age pictures are from the Isle of Bradon Nämforsen in Ångermanland, and two people in a hunting boat from the Repparfjord in Kvalsund which is often used in publications to illustrate Stone Age boats.

An interesting comparison is offered by boat pictures from the upper reaches of the Jenissei near Schalabolinsk on the mouth of the Tuba, investigated by Adrianow between 1904 and 1910. Unfortunately most of these pictures have since been destroyed by construction workers and only a few still exist as gypsum profiles in the Academy of Sciences collection in St Petersburg (Behn, 1950: 12–13). The largest ship motif was more than 90 cm long.

The boats at Slettnes and Alta, examined at the beginning of the 1990s, are currently the most northerly boat engravings in the world and also offer a useful comparison with those of Lake Onega and the White Sea (Stölting, 1997: 24).

The difficulties of interpreting these boat engravings

At present we are still unsure which ancient people carried out the stone engravings and what were their reasons and inspiration for doing so. Unfortunately not so many material finds exist that are sufficiently closely related to explain these Stone Age pictures. Attempts to interpret are not proofs.

Before we look at the composition as a whole, we

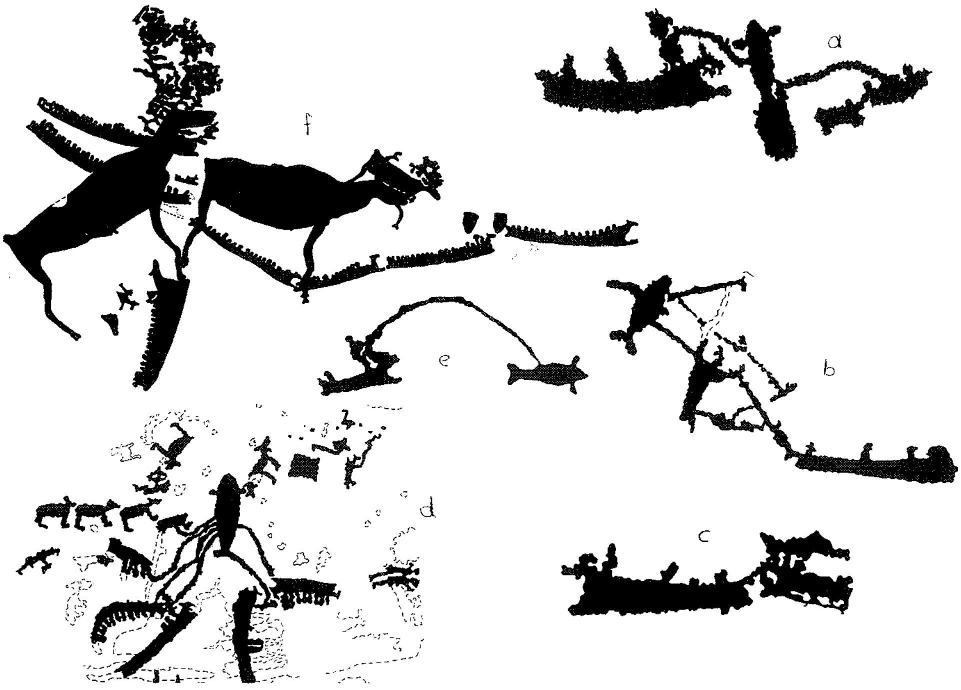


Fig. 25.1. Hunting scenarios.

must study each individual picture, for the composition may lead us to entirely different conclusions. Clearly picture compositions exist, but they are rare and difficult to interpret.

We do not know if the pictures are complete and how natural erosion has changed the engravings. I mention this because there have been some fantastic interpretations which have been further developed and have influenced further investigations.

Sometimes we see that the reproduction of the engraving was influenced by the ideas of the interpreter. However, using the Fotofrottage technique, rubbing the stone, we now have basic investigative material which is untouched by the personal views of the investigators. Poikalainen's publication on the northern territories of Lake Onega offers us further rationalistic standards of reproduction, systematisation and interpretation of this area.

An attempt at boat typologisation

In the existing literature no systematic approach to the typologisation of the Karelian boat engravings themselves has ever been made. Interpretation of boat pictures was mostly carried out as part of the hunting scenarios as compositions in general.

The question of whether skinboats or dugouts came first is a familiar one and has been more systematically studied since Hasslöf's publication in the 1970s. This question is particularly interesting when we look at the Karelian depictions. We have to consider the natural environment at the time when the rock carvings were made. What material could be used for boats which, the engravings indicate, could be more than 20 metres long and handled by more than 40 paddlers?

With regard to the materials used, the Devyatowa climate development studies show that pine and birch were the trees of the time (Devyatowa, 1988).

What could have determined the boat types?

In general the purpose determined the type. Clearly most engravings are concerned with hunting, either directly or indirectly. Meat meant life at that time and the people who knew the best places to find it had the best chance of ensuring their supply. This therefore determined, firstly, the transport function.

The engravings show that hunting was a major event at that time. Very rarely do we see pictures showing daily life with hunting for small animals the year round, rather we see hunting for reindeer, elk, whale, seal and swans. These animals were hunted, for the most part seasonally, on the White Sea and Lake Onega. Careful study of the scenarios enables us to say that the hunters came mostly from elsewhere using the waterways, which at that time were the best means of transport.

This purpose determines the boat type used:

1. to transport people and their weapons to the hunting places and get them back again.

   We can further assume that the hunt resulted in a lot of meat needing to be taken back and, therefore, very large boats. Thus characteristic:

2. to transport meat from hunting areas back to the winter quarters.

   Thousands of years later we have become very familiar with the organisation of seasonal fishing. We know the structure of the bays (wiecks) where many people from different countries came seasonally to catch herring, mostly in a mood of co-operation and often using detailed and strict rules. We also know that other people lived full-time on the wiecks. The native people were specialised in stocking the herring after the catch and that was strictly their privilege for the most part.

   On looking at the Stone Age depictions in Karelia, and at the boat engravings especially, we must revise our image of a very primitive population.

   With regard to seasonal hunting on the White Sea and Lake Onega we can assume that it was much more structured than we imagined. Different populations were organised in the efficient running of the seasonal hunting, which was also connected with the exchange of goods and telling stories of the year's events. All these things served as inspiration for the stone engravings.

   That so many people should come together when they normally lived in small groups also presented problems, especially when two particular circumstances arose: when less meat was gathered than planned, so that some people did not have enough; and when new people arrived, squeezing out the older population or obliging newcomers to fight for the right to hunt. Certain pictures leave us no other interpretation.

   This determines another characteristic of boats used:

3. fighting vessels.

   The fighting function could be determined in two different ways: ship against ship, ramming, for example. Or by bringing the fighters by the fastest means to the place where the conflict took place – such as we see with the vikings and their *ledang* system.

   People came to the Lake Onega and White Sea regions to hunt two types of animals: those living in or on the water – whale, seal and swans, for example – which gathered seasonally in large numbers before the winter; and those who, like elk and reindeer, gathered before starting long journeys.

   These animals could only be hunted efficiently by large groups of people. To secure them they needed boats which fulfilled a number of functions: 1. to frighten the animals, 2. to follow them, 3. to hunt them, 4. to transport the carcases.

Elk and reindeer, animals that are both heavy and swift, were caught by being driven into the water. Hunters in a line of boats led them in the direction of dry land and shot them before they could come out of the water again. The capes of Lake Onega are a very suitable place for doing this. Wrangel described this well following his journey to Siberia in the nineteenth century.

Compared with land hunting this activity has the advantage that the dead animals are all in one place, in particular in regions where there are no ravines. The carcases may then easily be transported by towing them behind the boats, when their buoyancy makes them much lighter than on land, possibly to places where others people may cut them up.

To summarise, the boats must meet many different demands:

1. the transport of cut meat,
2. the transport of people and goods during the hunting season;
3. the fighting function – therefore they must be strong and easy to manoeuvre, as well as be suitable for transporting people;
4. fast and manoeuvrable in order to follow swimming animals;
5. discrete enough to approach animals without frightening them (boats bearing an animal head on the stem;[2]
6. usable as help tenders for purposes other than hunting.

We may also say that while some of these purposes could be met by one boat type, logically not all of them may. Transport vessels are not usually quickly manoeuvred, for example. Therefore we may assume that more than one boat type or size was used during the hunting season.

If the hunters came from abroad we can further assume that the transport vessels came from further afield and could not be considered local boats from the two territories described. If the hunting boats could be easily and quickly built shortly before the hunting season started it would not make sense to transport the smaller boats, or tenders, as well. This means that after the departure for the White Sea and Lake Onega, the construction of the tender boats would form part of the general hunting preparations. We do not know whether these smaller boats were also used by local people outside the hunting season.

The "long keeler" (Fig. 25.2) – Type of Technology I

Given the knobs in the boat pictures indicating the crew members, and the one-metre space each needed to paddle (less for a passenger), the boats appear to be about at least 20 m long. However, the engravers' own imagination must be taken into account and we cannot be sure the boats were as long as this.

Nonetheless it is fascinating to see the Staraya Salawruga boat engraving which shows us 100 people in seven boats. According to Linewski, one knob indicates two people, which means that 200 people were contained in seven boats, either paddling or as passengers. This would suggest about 30 people in a boat around 20 m long and,

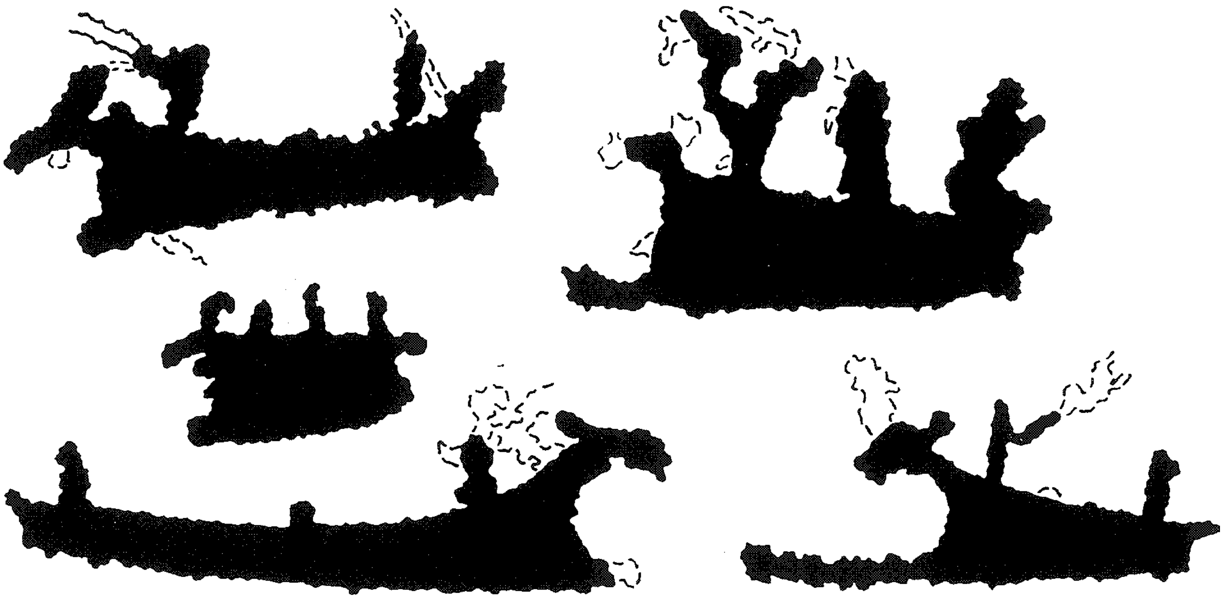


Fig. 25.2. The Longkeeler – Type of Technology I.

given the relationship of length to breadth, more than 2 m wide at the widest point. This reminds us of boats such as the Gokstad and Oseberg ships.

Also interesting from the point of view of the boat's shape (though of limited value in its interpretation) is a comparison with The Trieren and Dromonen from the Mediterranean.

Rational observations would exclude the possibility that transport boats of this size could be made of skin. We must, then, assume that these boats were made of wood, but of what kind and from where?

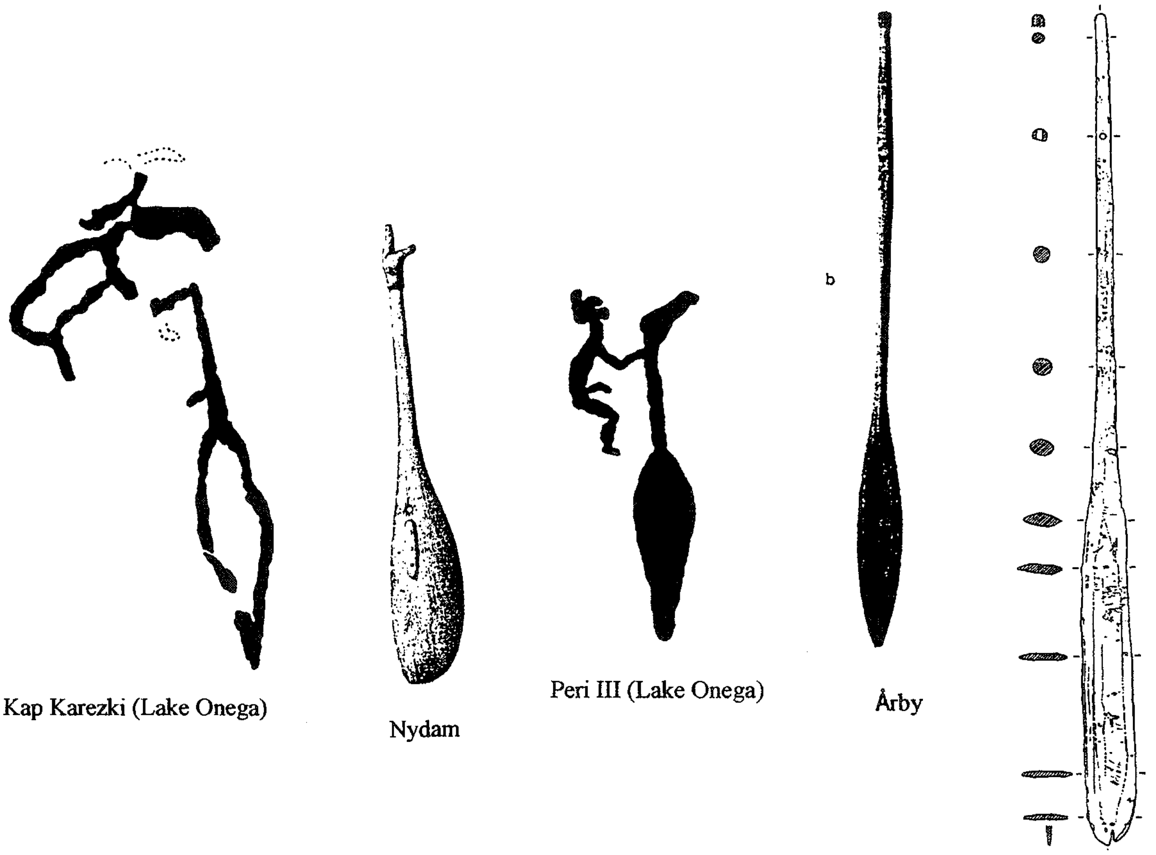
To build dugouts such as the Utrecht Ship very large trunks were needed and these were difficult to obtain at the time. These boats may have been built using some kind of planks, since the form – with the big gunwale and negative stem – would have been difficult to construct using the dugout technique.

According to Crumlin-Pedersen (1970), Rausing (1984), and Stölting (1997), the plank technique could be much older than so far thought. Bark would not have been a suitable material for a transport boat.

The transport of heavy loads suggests the need for a high-sided boat, which in turn raises the difficult question of stability. Thus the meta centre of a boat, of which the sides (according to Sawatejev) must be about 2 m high, must be near the waterline, otherwise the boat will tilt over. This problem must have been solved using weight stability and not form stability which was not developed until the eighteenth century in Europe. All this indicates a strong keel construction or a very wide boat.

The engravings suggest that the boats were quite fast and we could compare their speed with Asian dragon boats. However, given our knowledge of the areas we are describing here, the boats had to be easily manoeuvrable. Given their long keel-line, we can assume these boats had good course stability which could be improved by a sort of fin or sword. This may explain the small projections from the keel-line which could be the explanation of Stöltings tail on the stern of the boats (Stölting, 1997: 21). Such "long-keel" boats with course stability did not need added fins, however, and I prefer to think that the projection under the keel-line is a steering paddle (Fig. 25.1.c).

According to the main principles of shipbuilding technology, changing the direction of a paddled boat which could be as long as 20 m, is almost impossible without a steering paddle. What we have in these engravings (Fig. 25.3) could be nothing but a steering paddle, although Lauschkin interpreted it as a magic



Kap Karezki (Lake Onega)

Nydam

Peri III (Lake Onega)

Årby

Alsodde

Fig. 25.3. The steering paddle of Cap Karetzki and related shapes of steering rudder from the Iron age.

rudder and Linewski (Sawwatejew, 1984: 104) thought it was a bird.

The steering paddles from Kap Peri are therefore the two oldest depictions of a steering paddle I know. If we take this picture in conjunction with the elk picture adjacent to it, the composition could suggest that in order to catch swimming elk and reindeer, good steering is essential.

Skin boat technique (Fig. 25.4) – Type of Technology II

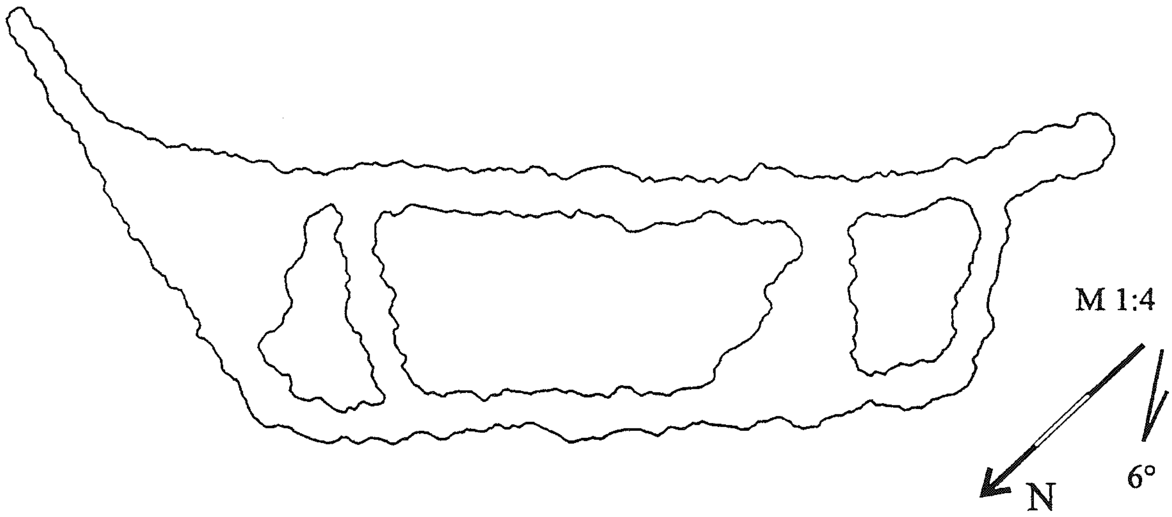
For stone age man it was common during the hunting season to see swimming skins in the form of escaping elks or rens. Fig. 25.4 does not leave us much room for interpretation. This is clearly a skin boat of the sort we find today among Umiak eskimos and used by women (Petersen, 1986).

The picture enables us to establish the boat's construction. It shows two main frames, but also without the usual elkhead; the long gunwale or keel is also absent.

If we date the stone age pictures on their artistic merit, the contour drawings are younger than the fully engraved petroglyphs.

The Dugout technique – Type of Technology III

The skin boat theory relies heavily on a comparison of the rock carvings with the boats of the eskimos, while the dugout boats are archaeological evidence. The differently valued horn from Husum, as mentioned (for example:



A-III-2 ▲ 1122.3-6.0 ● scaphomorph ● to the left? ● high, contoured hull: one triangular & two tetragonal unpecked areas ● without perpendicular lines ● LS 62 cm, P 4, V 3, D 5, I 6°, H 118 cm

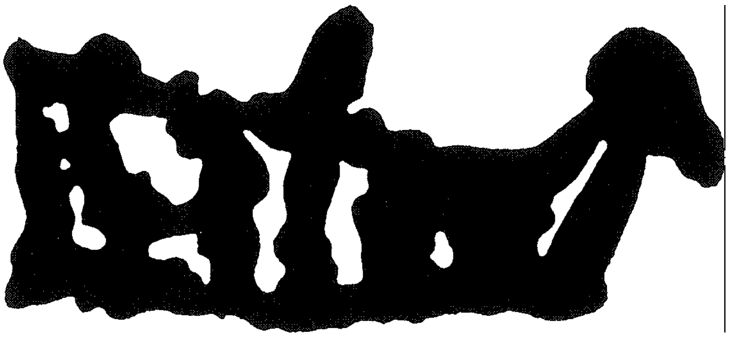
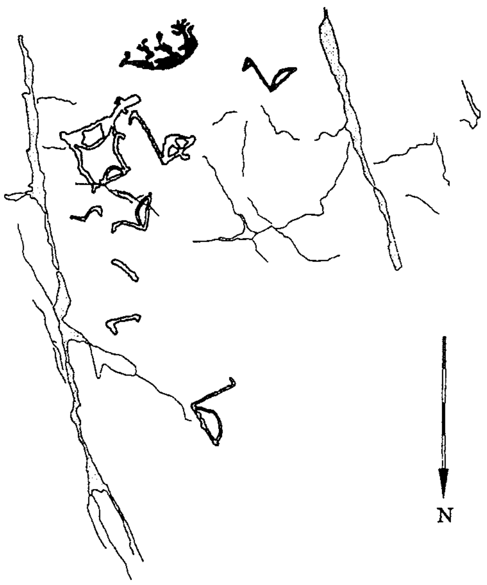
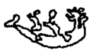


Fig. 25.4. The Skinboat – Type of Technology II (Lake Onega, up, White Sea, down). (Lake Onega, up, White Sea, down).





A-VIII-9 ▲ 1115.0-14.6 ● scaphomorph ● to the right ● partly broken ● convex, ornithomorphic(?) stem ● silhouette: concave upper line; convex lower line ● bow-shaped hull: high board ● long, phalaenomorphic poop ● dendromorph: five extensions ● two perpendicular anthropomorphs(?) ● LS 79 cm, P 2, V 1, D 3, I 5°, H 162 cm ■ carving connected with totemism (Autio 1987b: 199); ship with two anthropomorphs & tree? (Poikalainen, Ernits 1990a: 107); expression of the moon & Netherworld complex (= ship of decedents) (Ernits 1992a: 122)

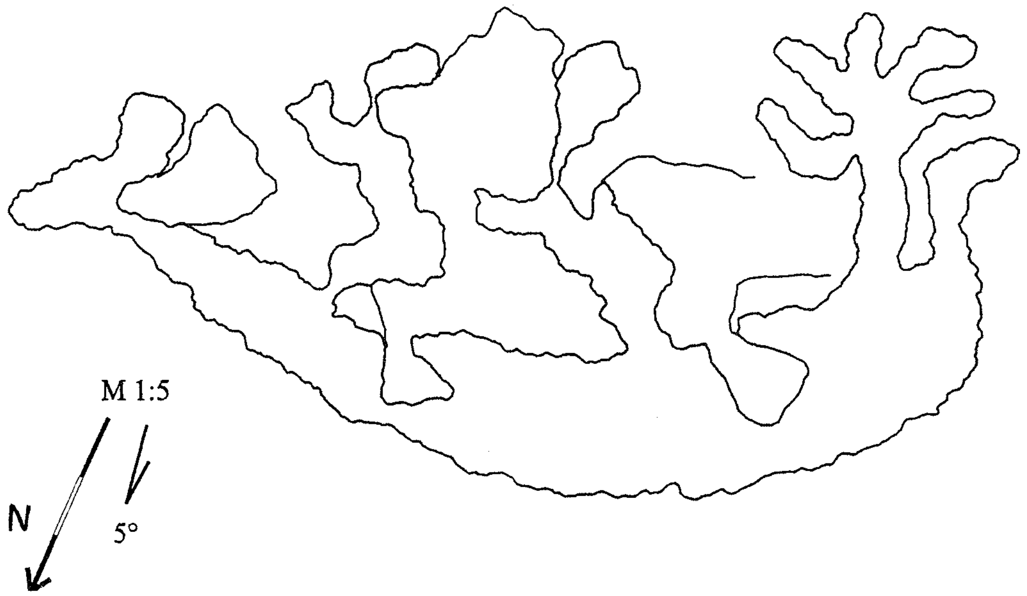


Fig. 25.5. The Logboat – Type of Technology III.

Ellmers, 1984: 41–55) could well have been used as a frame of a skinboat, it is so far the only archaeological remain of an skinboat. Stone age log boats are also known from Russia, although they have only been horizontally dated and some are no longer in existence.

So it is beyond doubt that these boats were used on water, although they were only manufactured in areas where suitable materials were available.

The Cape of Swans stone picture (Fig. 25.5) clearly shows us a boat of this type. In its shape with the elk head on the stem we see parallels to the logboat which was found on the stone age sites of Sventoji, Lithuania. Some of the elkheaded sticks which were found also at this sites in Lithuania and elsewhere could be removable fastened at the logboats using the hole which were investigated by Rimantiene during the excavations in the 60's last century (Riemantine, 1986: 177).

So the removable elkheaded sticks which were also used as a carried symbol on the land could be a sort of a special protection of the hunters in the stone- and bronze-ages as for example the crosses on some cog depictions indicating the protection of the traders in the middle ages. At the present stage of going through the evidence, it is the only picture showing a boat that may be considered a dugout which contradicts the theory that there used to be trees in Karelia which made the production of this type of boat possible (Poikalainen, 1998:37).

This suggests that material was in fact found to make these boats, or they were transported long distances. They might have been used in different ways. One use would be as traditional boats, another could be as a raft (in german Nachen) when several were tied together to facilitate the transport of more materials.

Looking at the archaeological evidence, particularly the stone age boat at Schchutchje in the Voronez region on the Don, which has scratch marks, we can also imagine they were used as a skate. The marks on the 7.55 m-long but narrow boat also suggest, them to be fittings for the type of boats used by the inhabitants of Polynesia (Brussjow, 1962: 51). I assume that these holes were used to fasten a fish net by putting wooden sticks through the holes (Riemantine, 1986: 177).

This means these boats could have reached Karelia without having been built there. A dugout boat more than 11 m long, found in Russia in 1911 but no longer in existence, was probably also used for long-distance travel. It is not known why it appears only once in the mentioned area, particularly since the boat shape ceramics are only seen as lamps.

Another detail of the Lake Onega picture is to be found behind the two stone age men paddling, and is considered by Pokalainen to be a tree (Fig. 25.5). We recall here the hunting methods of the Indonesians, for example, who sail towards their prey using a bush which is also a camouflage and usually found at the front end (Fig. 25.6).

This picture is certainly evidence of their knowledge of wind power which they may well have gathered by observing nature and, in this case, the swans often found in the stone age pictures.

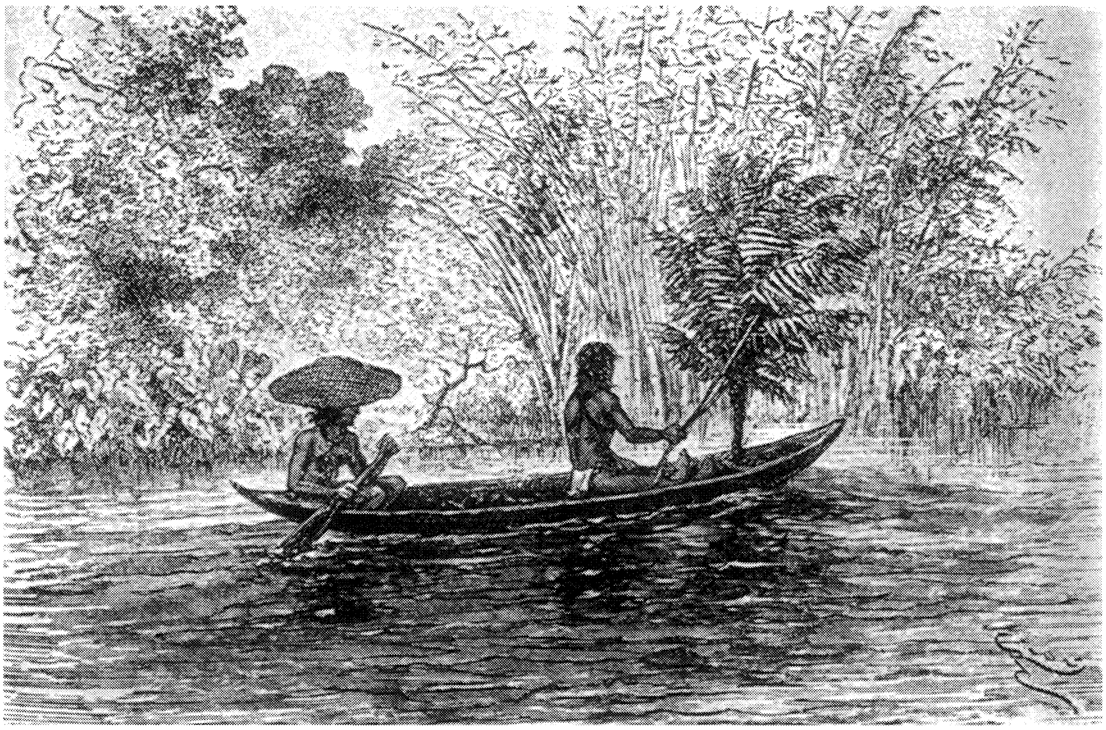


Fig. 25.6. A boat of Polynesia.

Notes

[1] Further observations (the south of the Onega complex) by Poikalainen are to be published in the coming years.

[2] Stölting is not right with his theses (Stölting, 1996: 18; 1997: 20), that all boats have an elk head, the boats from Schlabolinsk don't have an elkhead (see also fig. 8). The name *elkheadboats* (Stölting, 1996:20; 1997: 21) should be further discussed.

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26. A Roman River Barge (?) Found in the Danube near Prahovo, Serbia

Ronald Bockius

In remembrance of Prof. Petar Petrović, the late director of the Archaeological Institute of Belgrade.

About 15 years ago, former Yugoslavia in collaboration with Romania started a bilateral enterprise to share electric power between both nations, called the Djerdap ("Iron Gate") II projekt. On the Danube, 60 km downstream of the Iron Gate a large hydro-electric generation station was erected. The works are located at the Serbian town of Prahovo in the Krajina district, close to the border with Bulgaria (see Petrović, 1991: 296, fig. 57.1).

During building activities, which included the foundations of weirs and locks the water level of the river was been lowered for several metres. On the Serbian river bank close to the power station, there is an inlet which was already renowned for its Roman finds (Jovanović, 1996; artefacts in the Krajina museum Negotin).This site is named Kusjak. In 1986, when the water level sank near to its lowest mark, huge stone blocks, columns, architraves, and other finds came to light, scattered over a distance of more than 100 m along the river banks (Fig. 26.1). These archaeological remains have been identified as collapsed structures of a stone-built Roman habour dated to the period of Emperor Trajan *ca.* 100 AD (Petrović, 1991).

Owing to the costs and because of the urgent need to complete the building works, the state authorities forbade long-term excavations on the site. Surveys and some short-term investigations concentrated on certain areas were carried out by the local Negotin museum in 1986 and 1987. The Archaeological Institute of Belgrade took over the scientific responsibility. During field work, at different spots timbers were discovered. Whereas some of these materials have been interpreted as structural parts of a quay or an embankment (Petrović, 1991: 297) others can obviously be identified as ship finds. Separated from each other the remains of what was probably a single vessel were found in sector 1 and 3 lying underneath heavy stone blocks (Fig. 26.1). After their documentation by photographs and a set of plans drawings of wreck 2, the finds were dismantled for recovery. Finally, the treatment of the timbers took place in the near Negotin museum.

The head of the National Institute of Belgrade, the late Petar Petrović, spoke about the Prahovo excavation on the occasion of an international conference on Roman archaeology held at Canterbury in 1989; printed in the proceedings of the meeting as a preliminary report his short paper remained the only publication of the Serbian discovery because of the political situation in former Yugoslavia in the following years. Motivated by historical considerations only, Petrović suspected a military background of the Kusjak ship finds as with the late Roman Mainz wrecks (Petrović, 1991: 297). Expecting confirmation of his theory he invited the author to visit the site and the Krajina museum in 1996. Although, or perhaps because, the author's investigation led to a different interpretation of the Kusjak finds, he was requested to publish the materials.

Since the timbers have been treated with an obscure substance they are now in a very bad condition. To rearrange fragments appeared to be a hopeless puzzle, the more so as neither a code system nor sketches exist which could help to identify elements and their location within the ship. Moreover, clear ship components were mixed with the remaining wooden materials evidently missing in the documentation. So, the interpretation of the Serbian discovery has to be based mostly on photographs and drawings and not least on personal communications from those people who were involved in the excavation and wood treatment.

The excavators distinguished two wrecks found 40 m apart from each other (Fig. 26.1, areas 1 and 3). Wreck no. 1 appears to be a bundle of planks connected to each other by iron clamps. Remains of caulking material are visible, preserved for a short distance in one of the plank seams. Because similar observations were made on wreck no. 2 both fragments could be parts of a single vessel.

For wreck 2 slightly better archaeological data are available although some inconsistencies of the documentation are confusing to a certain degree (Figs. 26.2–26.7). Plans, drawings and photographs have obviously

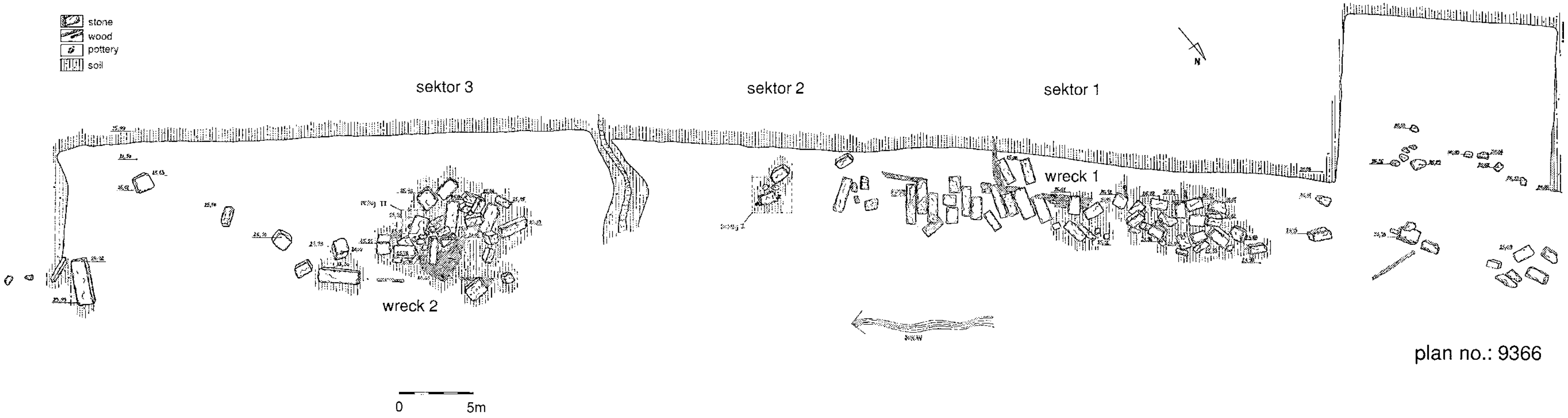

stone
wood
pottery
soil
sektor 3
sektor 2
sektor 1
N
wreck 1
wreck 2
plan no.: 9366
0
5m

Fig. 26.1 Excavation-plan of the Kusjak site along the south-western river bank of the Danube with the find spots of "wreck 1" and "wreck 2".

been prepared step by step in the course of excavation and recovery, but to variable standards of measurements and observation of details (see below). Wreck 2 is dated to the 2nd century AD by a coin of Emperor Trajan and a Roman brooch; the former is said to have been found underneath one of the frames (pers. comm. by P. Petrović). The timbers were thought to be poplar wood but a single piece taken to Germany was identified as oak. Whether or not the vessel had been built of different types of wood remains uncertain. After Petar Petrović died in 1998 it became impossible to receive further information.

In spite of the complicated circumstances and the unsatisfactory documentation the Kusjak finds merit interest for several reasons:

(1) together with the wreck of a barge found in a bog near Ljubljana, Slovenia, in 1890, recently dated to the 2nd or 1st centuries BC (Gaspari, 1998a; 1998b, each with references; see also http://www.waterland.net/navis [under Slowenia]), they are the only evidence for Roman inland navigation by plank built ships in south-eastern Europe;
(2) Kusjak throws new light on certain details of Roman ship construction on the periphery of the Mediterranean;
(3) the fragment called "wreck 2" appears to represent an unknown Roman ship type.

Wreck 2 is characterized by a flat bottom flanked by chine-blocks forming the transition to the ship's sides. According to a cross-section (Fig. 26.5) which cuts the wreck along a hooked line (Fig. 26.4) the chine-blocks are different in shape and size: the larger one, being longitudinally broken, is C-shaped in cross-section, and runs into sloping sides; the smaller one is L-shaped and passes over into vertical sides. As indicated by further details, the ground plan of that vessel was also asymmetrical. At least two of three floor-timbers preserved touched the vertical ship side with their horizontal portions whilst angled extension of the ribs ran against the sloping side planking. As far as preserved, the frames were connected to the ship's bottom by wooden nails, at least one rib, too, by an iron nail laterally driven from outside into the vertical part of the chine-block. The floor timbers were spaced at a distance of roughly 60 cm, but the plans seem to be incomplete because only one of the frame's treenail joints has been sketched (Fig. 26.7). Nothing suggests that any frames are missing, so the internal arrangements of the timbers was also asymmetric. The same seems to be true regarding the outline of the strakes which indicate a hull which narrows on one side but presumeably not on the other. The bottom is longitudinally rounded, as is one side; but it is uncertain whether the other side of the vessel had a similar curve vis-à-vis.

Near the broader end of the wreck which was somewhat less than 4 m long, the width amounts to 1.7 m, measured at the bottom of the ship. At the same section an original height of at least 1.2 m can be deduced from the collapsed side planking. The longitudinal base-line of the ship's bottom cannot be traced back precisely, but it seems that the sides of the vessel may have been rather more than 1.5 m in height.

Since we do not know to what extent the wreck is distorted it is impossible know the original shape of this

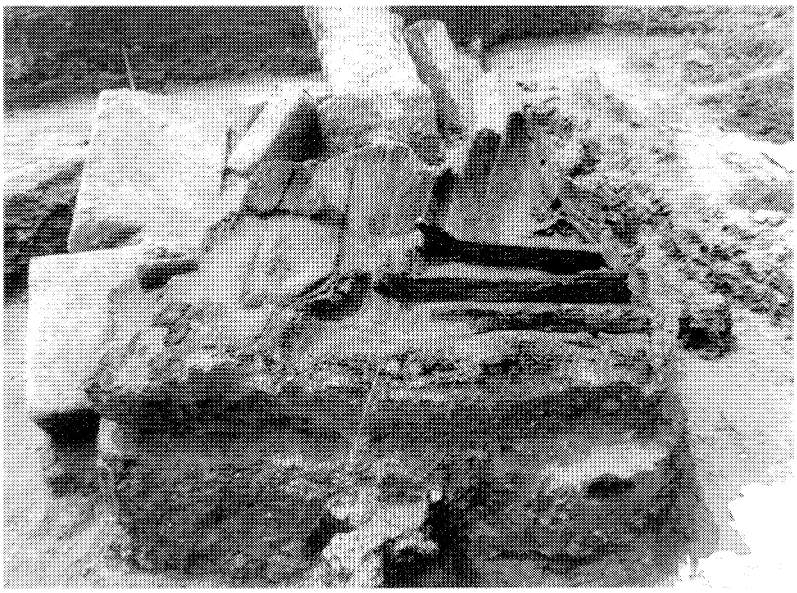


Fig. 26.2 Kusjak "wreck 2" with a view of one end seen from inboard. Note the rise of the floor, and to the left, the collapsed side which was originally adjacent to the sloping portion of the floor-timbers.

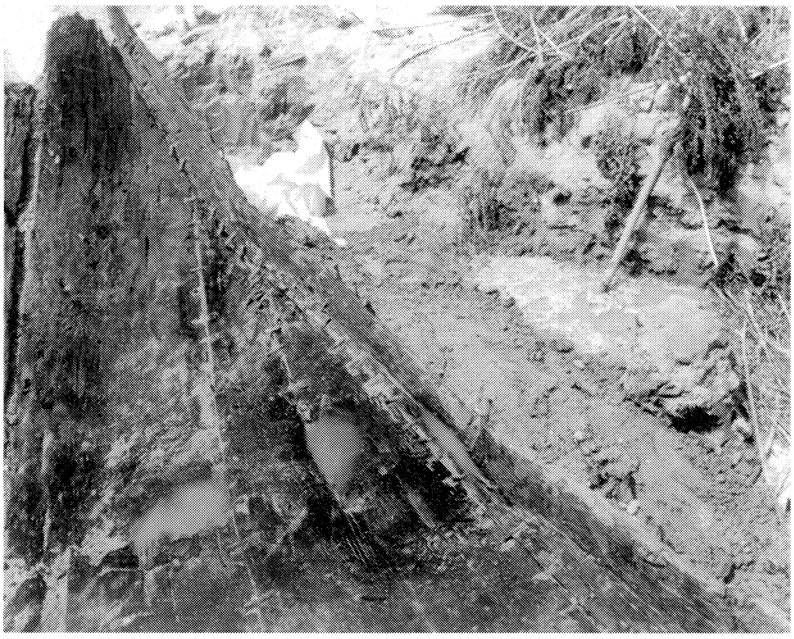


Fig. 26.3 Sectional view of an end of wreck 2 with iron clamps scattered along the plank seams. Note also the clamps at the upper edge of the L-shaped element.

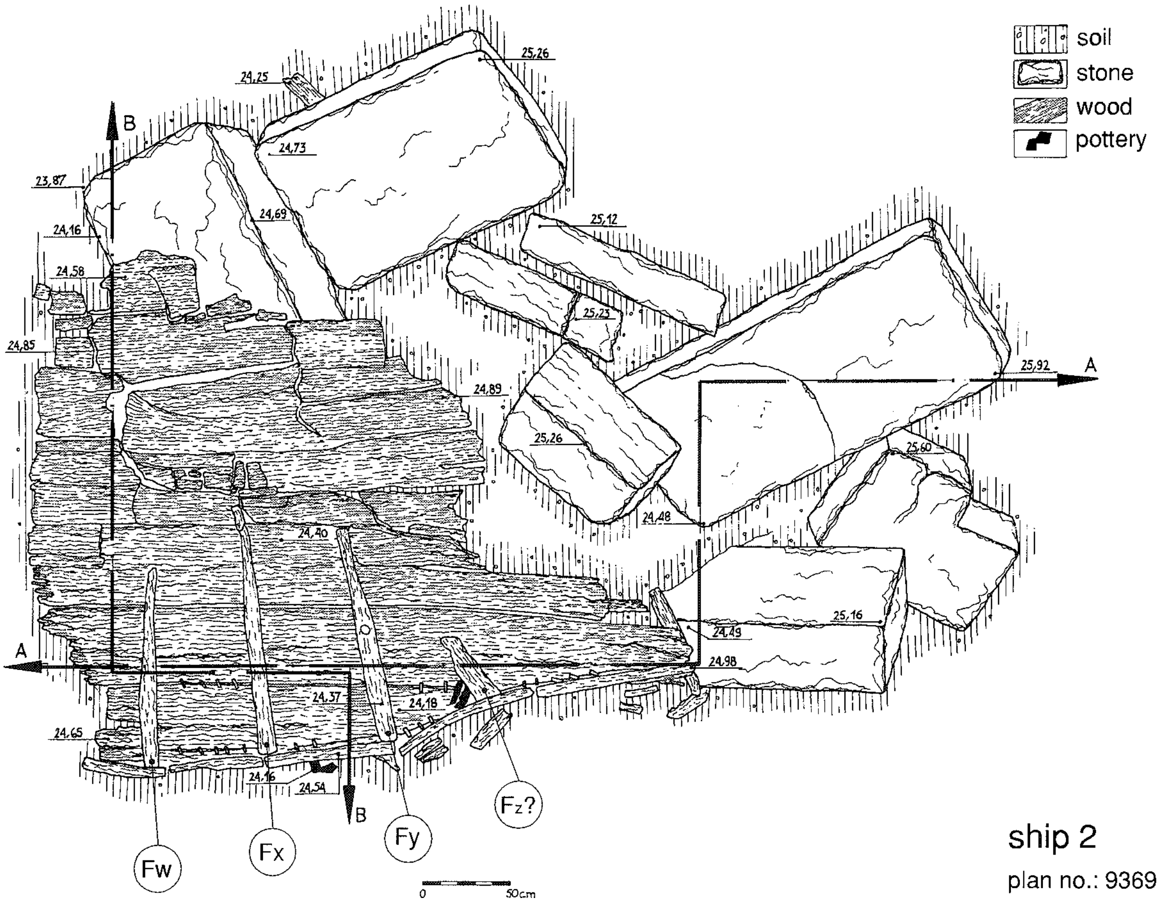
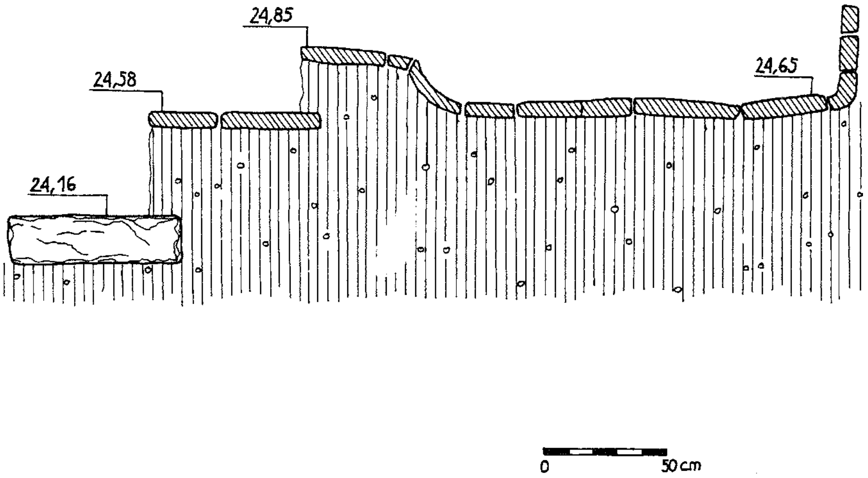
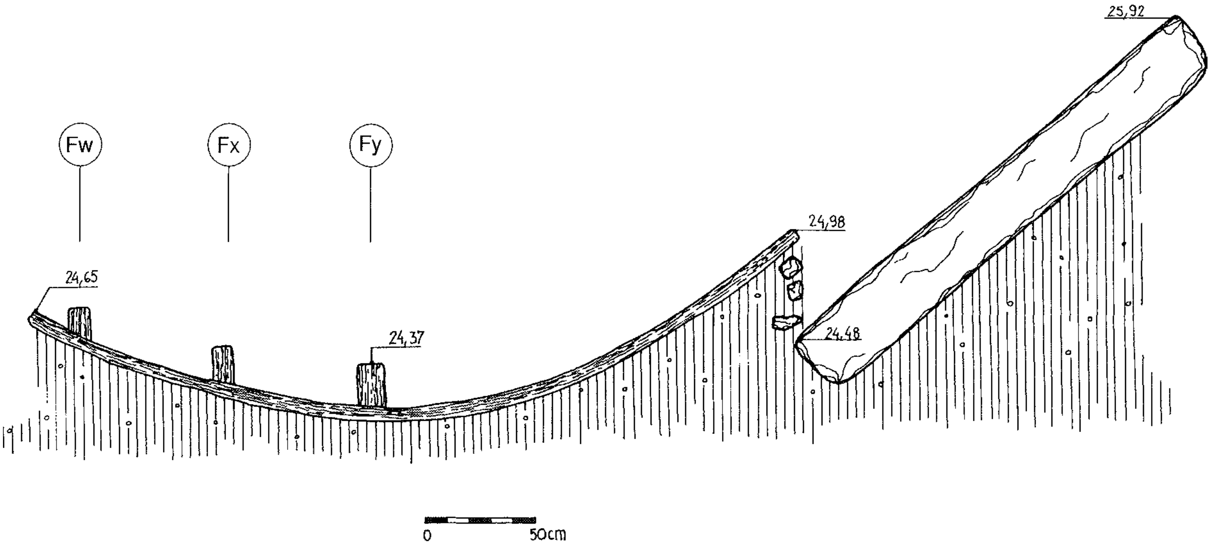

soil
stone
wood
pottery
25,26
24,25
24,73
B
23,87
24,16
24,69
24,58
24,85
25,12
25,23
24,89
25,26
25,92
A
25,60
24,48
24,40
25,16
24,49
24,98
A
24,37
24,18
24,65
24,16
24,54
B
Fz?
Fy
Fx
Fw
0
50cm
ship 2
plan no.: 9369

Fig. 26.4 Field-drawing of "wreck 2" with three or four frames in place. Axes AA' and BB' correspond to the cross-section Fig. 26.5 and the longitudinal section Fig. 26.6.


24,85
24,58
24,16
24,65
0
50cm

ship 2
section BB
plan no.: 9372

Fig. 26.5 Cross-section of "wreck 2" following axis BB'(see Fig. 26.4).


25,92
Fw
Fx
Fy
24,98
24,65
24,37
24,48
0
50cm

ship 2
section AA
plan no.: 9371

Fig. 26.6 Longitudinal section of "wreck 2" following axis AA' (see Fig. 26.4).

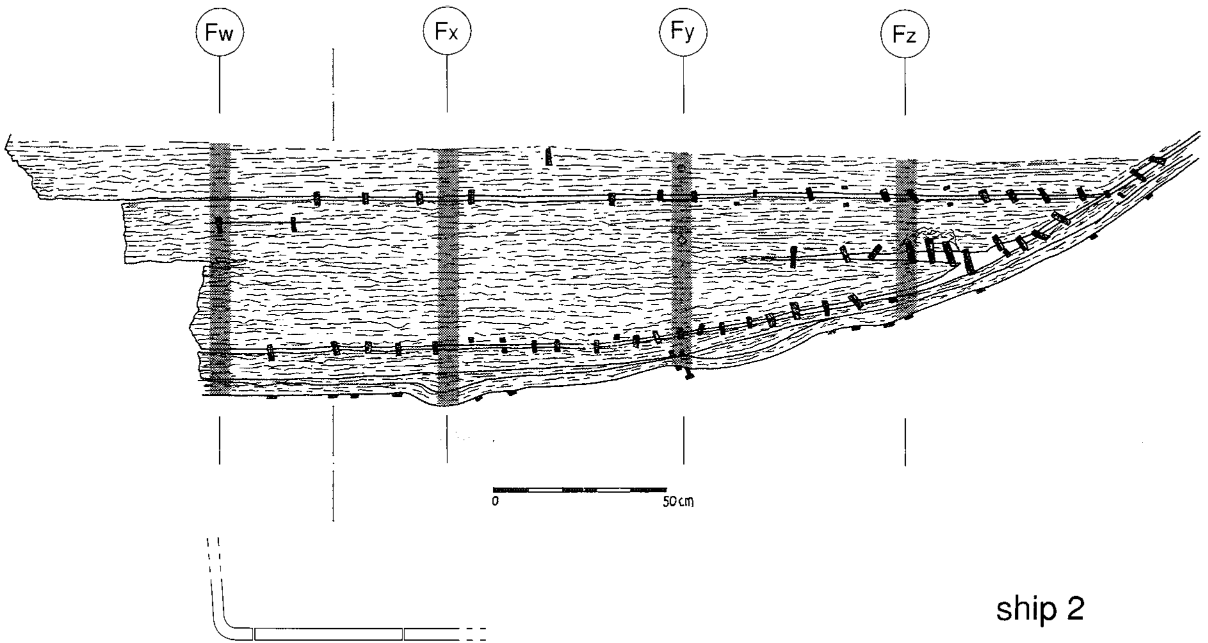


Fig. 26.7 Section of field-drawing Fig. 26.6 with frames removed, and a provisional cross-section of the same wreck portion. The hatched areas marks the position of floor-timbers (Fz uncertain). Some details, for example the numbers of nails and clamps, or the accuracy of the scale, contradict the wreck plan given in Fig. 26.4.

ship. Obviously, she was flat-bottomed with near-rectangular sections due to the use of chine-blocks. From this point of view the vessel can be compared to the various Gallo-Roman barges found in the northern provinces as well as south-east of the Alps (see Bockius, 2000: 121, fig. 13). Unlike these, however, wreck 2 was sharp ended rather than swim-headed and the bottom planking rose to the fragmentary end of the ship without any transition (Figs. 26.2 to 26.3 & 26.6).

In addition to those meagre results other observations of ship construction seem to be noteworthy. As demonstrated by photographs of wreck 1, *Kusjak 2* is characterized, too, by an unusual system of plank joints. Arranged inboards along some of the plank seams iron clamps fasten the elements together (Figs. 26.2 to 26.4 & 26.7). Clamps were also used to repair cracks (Fig. 26.7). Also a now-missing side strake had been fastened to the chine-block by iron clamps, which were hammered over the external edge of the seam (Fig. 26.7). According to the documentation, the sequences of joints of the bottom-planking are interrupted at certain points; probably, details were not properly mapped (compare Figs. 26.3, 26.4 & 26.7). Considering short distances of only 5 to 10 cm, the arrangement of the metal fittings resembles the scheme of stitch holes in the planking of ancient sewn ships (for example Beltrame, 2000, figs. 1–4). From a typological point of view, similar clamps are used in medieval and later vessels to hold in caulking materials (Arnold, 1992: 89–94; Vlierman, 1996: 49–64 tab. II nos. 1–15.17–18). The same type of clamp occurs in the Roman-age shipwrecks fromYverdon-les-Bains/CH, Zwammerdam/NL and Oberstimm/D as elements of the assemblage of planking or to repair cracks (Arnold, 1992: 35 with figure), the former two being members of the Romano-Celtic tradition, the latter being built with mortise-and-tenon joints. In the Zwammerdam 2 barge, dated to the 2nd/3rd century AD, iron clamps reinforced the transition from the amidship section to the swim-heads (De Weerd,1988: 103 figs. 51;54 with detail B&C; 59) whilst in one of the two river boats found near a Roman camp at Oberstimm, iron clamps fastened the seam between the sheer strake and a wale after the mortise-and-tenon joints had been broken; the same traces occur in both *Oberstimm* wrecks (which can be dated to shortly after 100 AD) along the seams between keel and garboard strakes to strengthen their fore body. The unusual construction method of the *Kusjak* vessel suggests a Roman date is attested. However *Zwammerdam 2* and *Oberstimm* themselves imply technological links to the Mediterranean ship building tradition of sewn planking: the frames of *Zwammerdam 2*, show sets of "limber holes" cut in the lower face of the floor timbers over each seam. Such a procedure seems to be completely senseless for a vessel without stitched seams when caulking would have protruded inboard. So, there

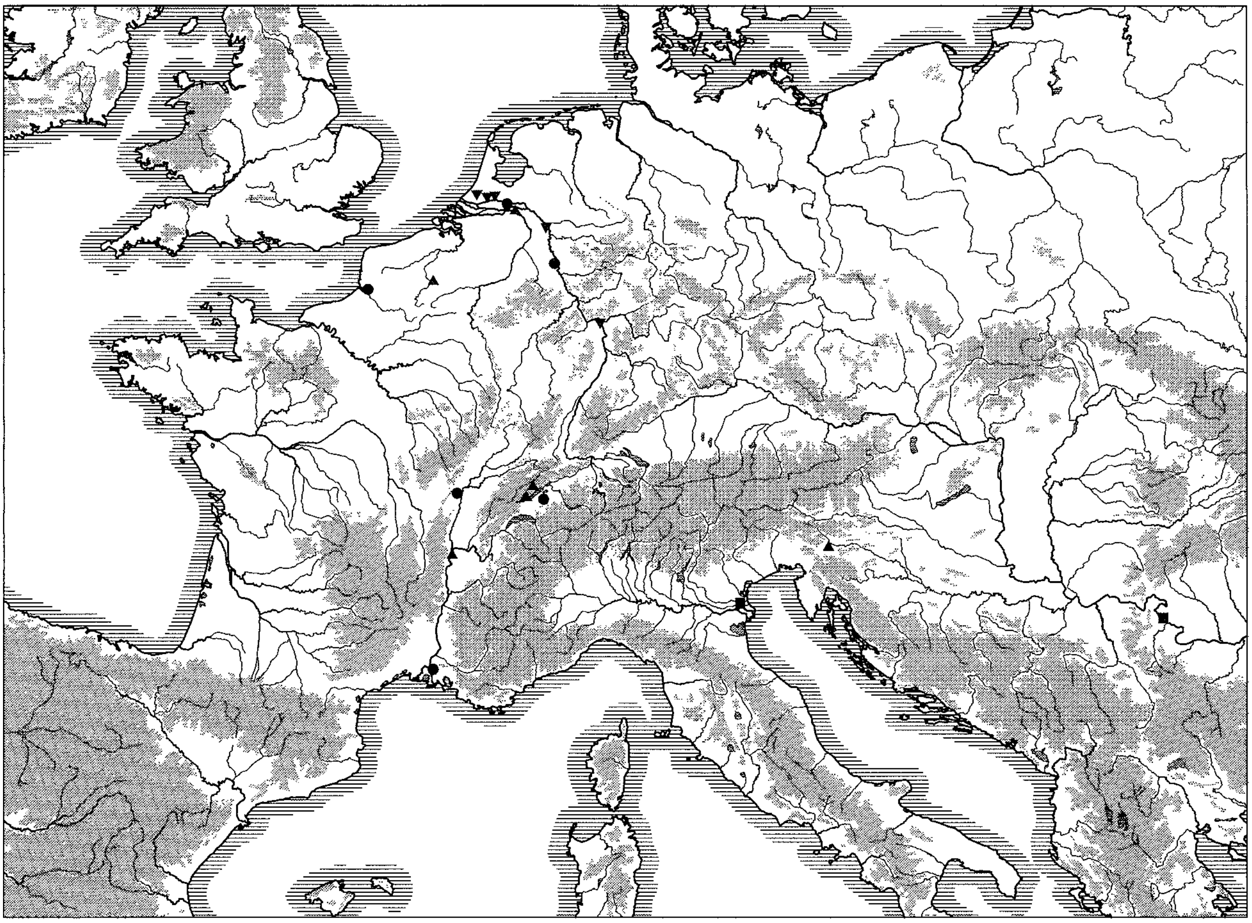


Fig. 26.8 Distribution map of ancient flatbottomed inland vessels. The symbols distinguish prams of Rhenish building technique with overlapping side planking (triangle with lower tip), carvel-construction (triangle with upper tip), unknown planking techniques found abroad (circle), and ship finds of related type (square) (after Bockius, 2000).

might have been influences from the Adriatic region to Roman ship yards on the Rhine (De Weerd, 1988: 295–300, 316). The same could be true for the other wreck mentioned: the river boats from the upper Danube were built essentially from pine and oak wood, the frames attached to the shell by treenails according to the Classical tradition. But, surprisingly, the plank seams were filled with cords of lime-tree fibre (*tilia*), *i.e.* the same material used to caulk the Comacchio and Ljubljana ships from the 1st century BC (Castelletti *et al.*, 1990:158; Gaspari, 1998b: 534, 538).

The constructional details of the *Kusjak* wrecks look strange even for ship finds from the periphery of the Mediterranean world. But one may ask: what do we really know about ancient inland vessels of southern Europe? In principle, the building techniques of wreck 2 approach more to the Romano-Celtic tradition because of the extensive use of iron the more as mortise-and-tenon joints are definitely missing. The tight sequences of iron clamps fastening the strakes together seem to be a substitute both for the complicated building procedure and the expensive maintenance of ancient sewn ships. This is not a particularly convincing proof of technological links to the Roman (and medieval) sewn plank boats of the Adriatic. But there may be a further clue:

Notwithstanding the poor preservation and the unsatisfactory circumstances of the *Kusjak* finds, two observations can be taken as facts: the vessel was flat-bottomed with steep sides; the transition from the bottom to the sides was moulded by chine-blocks (Figs. 26.4–26.6). These are features and elements of Roman barges to be found in the northern provinces and – proved by the Ljubljana wreck – near the *caput Adriae*. The latter ship represents a particular version of the type because she is the only specimen of stitched construction and because her ends seem to have been of unique shape (comprehensively Gaspari, 1998a: 193–197, figs.9–12; 1998b: 531–536, figs. 2–3, pl. 70.1). Another wreck found in a Roman settlement at Corte Cavanella (wreck no. II), province of Rovigo, Italy (Sanesi Mastrocinque *et al.*, 1986; Beltrame, 2000: 91–94, fig. 3), belongs to the same group of sewn ships. Flat-bottomed like the Ljubljana barge, the *Corte Cavanella II* find has a sharp-ended hull (of which only the bottom-planking survived) similar to that of *Kusjak 2*. Although differences exist, all plank-built inland vessels known from Italy and former Yugoslavia are related to each other to a certain degree. As is well known, in the area around the Adriatic Sea, ligature technology played an important role in Roman shipyards, but probably not everywhere in that zone except locally. This suggests that the builders of the *Kusjak* ship(s) had been inspired by the sewing technique which they apparently transformed to a more practical solution.

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27. Expanded Logboats between the Baltic and the Black Sea

Waldemar Ossowski

In 1995 the Polish Maritime Museum in Gdansk started work on a catalogue of all logboats from the areas of Poland, as a result of which approximately 200 historic craft in Polish museums have been catalogued so far. The chronology of many boats in this group was determined by methods of absolute dating. During these examinations, we also gained information confirming the knowledge of expanded logboats technique in Central and Eastern Europe (Ossowski, 1999).

The problems concerning expanded logboats are a much-discussed matter in the boatbuilding literature within the frames of the considerations on the genesis of plank boats (Crumlin-Pedersen, 1972; Gifford, 1993; Sorokin 1994; van der Mortel, 2000). The expansion technique is convincingly proved in Europe for the areas of Scandinavia and the coasts of the Baltic and the North Sea beginning from the Roman Iron Age (Crumlin-Pedersen, 1991).

The problem of recognition of this technique in the archaeological material raised much discussion (McGrail, 1978: 41). In 1991 Ole Crumlin-Pedersen presented the criteria for the identification of logboats in the archaeological material, built with this special technique. These principles were used to separate this group of logboats from the crafts catalogued on the Polish territory.

The eldest remains of expanded logboats from the Polish areas come from the boat graves in three cemeteries of the Wielbark Culture in Weklice, Ulkowy and Masłomęcz dated to 1st – 3rd century AD. The most numerous group of such objects was recognised in the cemetery in Weklice. The Weklice cemetery is situated 5 km inland from the present Druzno Lake and 20 km of the estuary of the river Vistula to the Vistula Lagoon.

Recent researches have proved that in the end of the 1st century AD, within a short period of time there were established numerous cemeteries and settlements belonging to Wielbark culture. In this time main bed of the Vistula river was falling into Baltic Sea with the eastern arm and its remnant is Druzno Lake (Fig. 27.1). The population along the west and south edge of the Elblag plateau was also quite dense. In zone contiguous to the former bay, within the range of 40 km was found 43 cemeteries and more than 70 traces of settlements. The locality used all the cemeteries till the end of the 3rd century. Later all of them disappeared (Okulicz, 1991). Archaeological sources are associated with the residence Germanic tribes of *Gepidos*. According to the legend described by Jordanes they reached on ship Vistula mouth from Scandinavia. In the discussed period this area was then one of the most important sites in the Baltic region. From there amber extracted from Sambia Peninsula and collected on the Vistula Lagoon shores was transported to the Roman imperia. Comparing the amber artefacts from coastal sites, it seems quite evident that between the 2nd and the 4th centuries AD the local amber workshops on this area produced a large variety of amber decorations

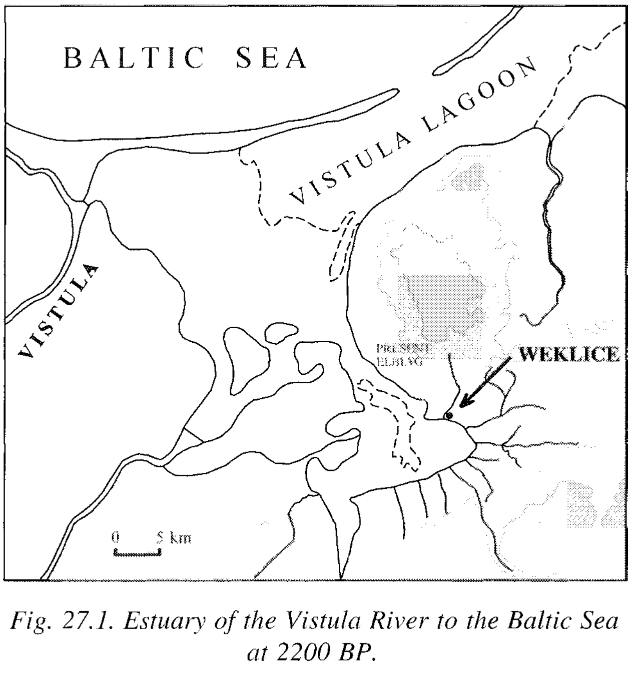

Fig. 27.1. Estuary of the Vistula River to the Baltic Sea at 2200 BP.

of a high quality. The most common of the amber items made then were cylindrical and octagonal beads. The well-developed commercial links between the Barbaricum and the Roman provinces necessitated trading routes. The best – known of these the Amber Road, ran from Aquileia in northern Italy, past the environs of Vienna, and finally along the Vistula right down to its mouth. In 3rd centaury the main direction of Amber Road led from Vistula River across present east Polish border to Black sea area. It was also connected with the migration of Germanic tribes *Gepidos* and *Gutones*.

Newly discovered 2nd century boat graves from Weklice provide us with new data concerning expanded logboats used in central Europe in the Roman period. During the excavations, carried out here by Jerzy Okulicz from the University in Warsaw since 1984, about 506 inhumation and cremation graves were found (Okulicz, 1991; 1992). The locality has been used as a burial ground from the second half 1 century AD till the end 3rd century AD. Because of the agriculture works and soil erosion more graves in the upper layers have been destroyed. The graves were orientated according to the line NS with their heads on N and insignificant deviations. The cremation graves lie side by side with ones containing skeletons. The slope is covered with light, sandy soil. While rotting the wooden objects left a faint trace in the light sand. It particularly applies to the dark traces in the light sand left by wooden and other organic materials. In consequence of the soil conditions the outlines of the organic containers used to bury the dead have been preserved as remarkably complete soil stains. In earlier phases there had been log coffins in use. Later, board ones took their place, while the grave holes were boarded. In 5 graves there were the traces of boats that were documented with traditional methods (Fig. 27.2). The nature and details concerning the grave boats cannot be determined directly, similarly to the finds in which the timbers has been preserved. Here, in this case, the nature and details must be deduced from drawings, notes and excavation mounts. On the basis of the analysis of the imprints in the sand it has been possible to determine the nature of the boats used in graves. Boats marks differ in having a seaworthy shape with pointed ends from the marks left by the straight-sided trunk coffins. While excavation works in Weklice

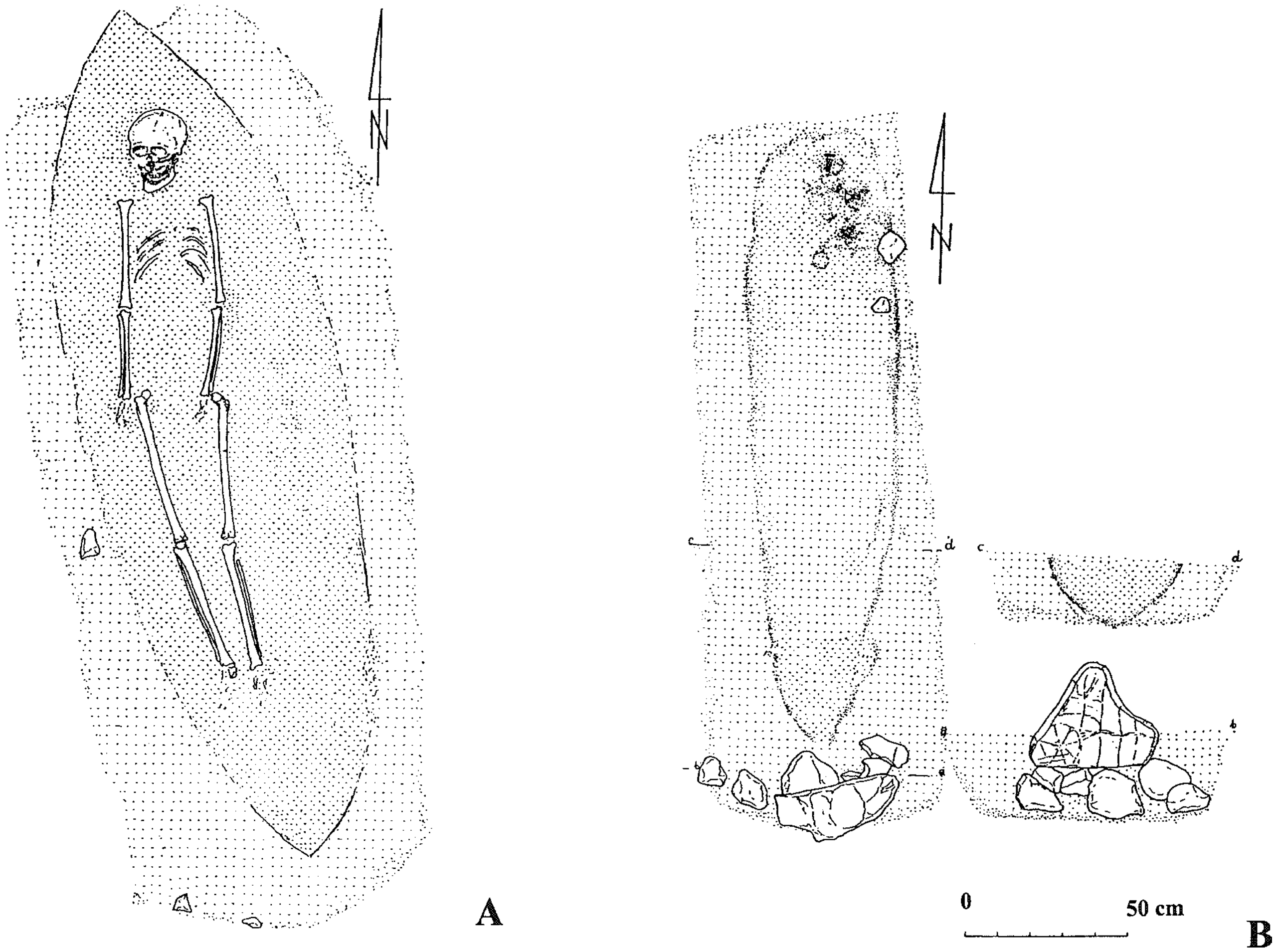

Fig. 27.2. Plan of the boat graves from Weklice A -Grave 383, B – Grave 360. Drawing: Jerzy Okulicz-Kozyryn.

the boat-graves were recognized as the ones requiring especially careful excavation, and survey and special documentation techniques had to be developed in the field. This traditional technique gives only a little information about the ends and other details of the form.

In 1998, in the last season of excavations, the author participated in the works in order to catalogue precisely the remains of newly discovered boat graves. During these research works, it was possible to document the traces of parts of 3 half boats using series of cross and longitudinal sections (Fig. 27.3).

A particular feature of the cemetery in Weklice is that the younger graves were built on the older ones. In several dozen cases there is overlapping stratigraphy. According to J. Okulicz it is a characteristic feature of the open character of the group formed in this area. The group was joined by people from different parts of Europe interested in the amber trade. The cemetery was open all the time and the memory of individual graves faded away (Okulicz, 1991;1992).

There is one size of Weklice boat – average lengths of 2 – 3 m. No metal fittings were used in their construction, all have a characteristic tapering plan, showing that they derive from tree trunks. Although a clinker built construction, with strakes fastened by wooden pegs is a theoretical possibility, all boats have features strongly indicating, not to say proving, that they were a logboats. The main part Weklice boat consisted of thin-walled and elegantly formed logboats. There are expanded logboat hewn as a thin walled and stretched into a more open boat in comparison with the parent logs: of cylindrical or conical form.

The traces discovered testify to the spindly shape of the boat with similarly formed stem and stern forms. They are 160–420 cm long and 50–80 cm wide. The prepared cross sections showed roughly the semi-circular form of the boat with the preserved height of 20–35 cm on the midship. In the documented outlines there were no elements forming plank boats, such as: keels, ribs, planks or stems. There were no traces of iron rivets, either. The outline of the board's line, the form of the bottom and endings suggest that these are the remains of the logboat with artificially expanded sides. At the place of bringing the grave goods, sometimes there are still fragments of wood that were subject to detailed analyses. Owing to botanical examinations, it was possible to recognise oak in two cases. In some samples thin layers of charcoal were noticed, which probably resulted from heating while expanding the hollowed and wet log. During the examinations of the samples, the presence of tar was also observed, which must have been connected with the conservation of the wooden craft.

Expanded logboats were found in several parts of the Europe, with Bornholm as the nearest locality in recent times in relation to Weklice. It became immediately apparent that Weklice logboats are very similar to those excavated at Slusegård in 1958–1964 and examined by O. Crumlin-Pedersen (1991). The similarities between the Weklice boats and the Slusegård ones are strictly apparent. The principal parallels are construction, chronology and origin. They were also preserved in exactly the same way. In size, the Weklice boats fit into 3 m length category from Slusegård – a short, tubby boat. The constructional similarities refer not only to the general method of

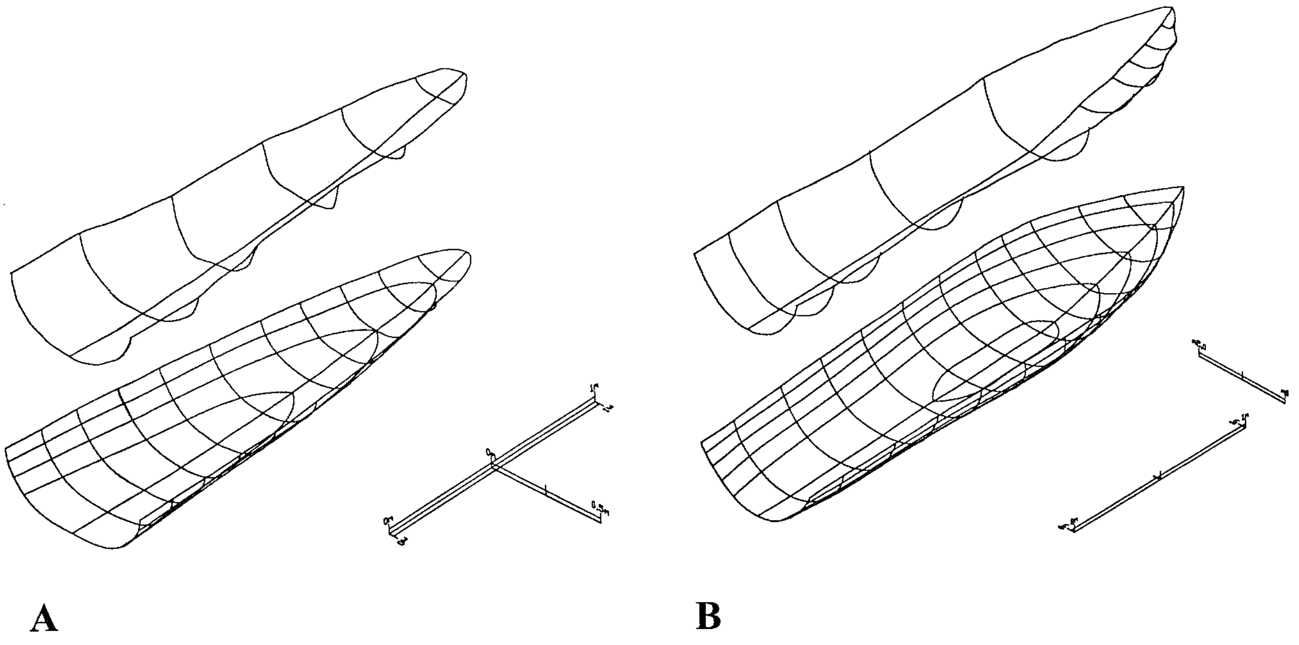

Fig. 27.3. Reconstruction of the half boats from A-Grave 455, B- Grave 452.

construction, but also to the details. Some of the Slusegård boats were similarly charred.

The parts of the boat used at the burials were undoubtedly deprived of ribs in order to make space for the grave. The only archaeological evidence about the form of ribs at this period of time in the mouth of the Vistula River are two objects discovered during archaeological excavations in the Puck Bay (Litwin, 1996). These are two ribs 1.4 and 1.85 m long, with the outer edge damaged – showing the traces of lashing holes on the sides. The radiocarbon examinations testify to the fact that they come from the same period as the boat graves in Weklice.

The initial publications concerning the discoveries of boat-graves in Weklice led to further information on other similar findings (Ossowski, 1998). Three similar boat graves of this kind were found in the cemetery of the Wielbark Culture in Ulkowy near Gdańsk (pers. com. Tuszyńska,) and another one in Masłomęcz in southeast Poland (pers. com. Gładysz). Unfortunately, all the newly discovered graves were being explored with no special techniques that would allow reconstructing these craft in every respect.

An example of medieval expanded logboats is a boat from Kazimierz Pomorski not far from the coast of the Baltic Sea discovered accidentally during reclamation work (Lachowiczowa, 1969; Ossowski, 1999: 123, fig. 80). As early as at the moment of discovery the boat was damaged because of being cut in three places (Fig. 27.4). On account of archaeological examinations the sizes of the boat were established as follows: the length 9.35 m, the width 95 cm, and the height 40–50 cm. The craft is characterised by a very gentle transition from the boards to the bottom and a circular cross section. The bottom and the boards are thick, and the sides bend at places to the inside, which may testify to the tendency towards the return to the original trunk-like form. On the discovery, the width of the monument was twice its height. During the excavations no transverse supporting elements were found, but it was noticed that the boards of the logboat were equipped, just beneath the edge, with oval openings with the size 2 – 4 cm, with irregular pauses of 0.5 – 1.05 m between one another. We cannot exclude the fact that they might have served as the place for fixing thwarts supporting the expanded hull. The logboat has traces of repairs in the form of patches fastened with wooden pegs and additionally caulked with moss. Moss was also used as caulking for the inside fractures in the log. The pegs might have also serve as thickness gauges gauging in the bow part of the boat, where hollowing was difficult because of some knots from the trunk crown. The boat was built of oak. It was possible to take out a sample from a preserved bow fragment for dendrochronological analysis, due to which it was established that the tree for the building of the boat was felled in the years after 952 AD.

Another expanded logboat comes from the late Middle Ages and it was discovered in Sierzchów on the Rawka River in central Poland (Głosik, 1964; 1966). This logboat was built of oak. The sizes of the seriously damaged hull were following 7.23 m in length and 1.8 m in width (Fig. 27.5). The oval bottom part was 7 cm thick, decreases gently to 2 cm at the board's edges. At a distance 2.2 m from the preserved end there existed a natural rib, fixed to the hull with two wooden pegs situated at the ends of the boards. The only Polish logboat with expanded sides of known age is the oak from Sierzchów dated at 730 ± 50 BP (Ossowski, 2000: 65).

In the hull of the boat from Sierzchów there are rows of thickness gauges nailed up with pegs and grass seals (Prosnak, 1969). Moreover, additional openings with smaller diameters are located just at the edges of the boards and testify to their being linked with further elements, like additional strakes. At present, it is impossible to examine this boat, because it was purposely drowned in a lake due to the funds shortage for conservation.

The areas of Poland do not provide any materials illustrating the usage of expansion technique in the modern times. The neighbouring eastern regions in the basin of the Prypeć River – characterised by abundant forests and frequent reservoirs – retained the reports of Polish researchers and travellers from 19th century on the usage

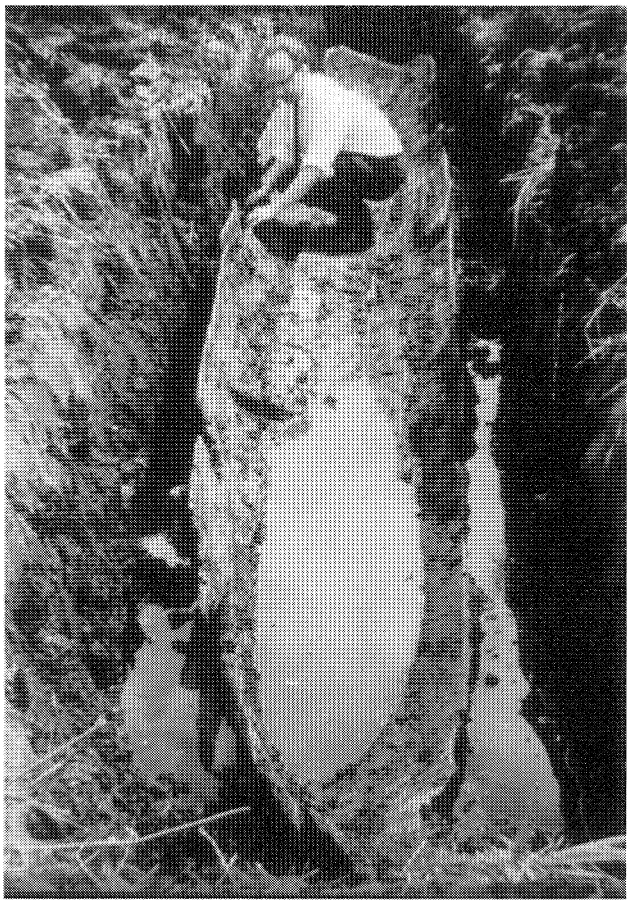

Fig. 27.4. Oak logboat from Kazimierz Pomorski during exposure in 1968.

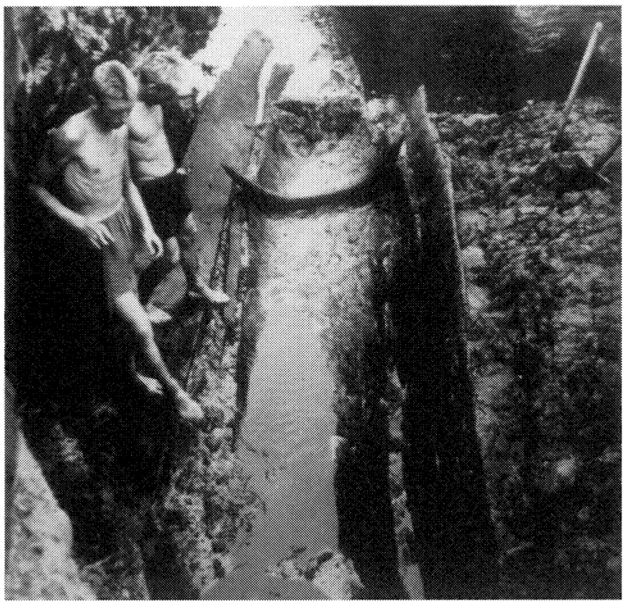

Fig. 27.5.Part of the 13th century expanded logboat discovered in 1963 during archaeological excavations at Sierzchów.

of the boat built with this technique. O. Kolberg gives some information concerning this matter recording three different names of these kinds of boats depending on the size (1968: 191, 249). All of them were constructed of heated oak, while the hull was additionally completed with pine planks. The largest of them could take on 1.6 – 4.8 tonnes of cargo (Raczyński, 1839: 42). Such boats disappeared at the end of 19th century, since there is no information on this sort of craft from the twenties of the 20th century, when these areas used to belong to Poland. C. Pietkiewicz, a Polish ethnographer working then in this region, remarked merely in his short description of these boats that while building a logboat, the locals bored thickness gauges in the whole of the trunk surface and sealed them with treenails after the vessel had been dried (1928: 170–171). This description confirms the knowledge of boatbuilding techniques for the construction of logboat with expanded boards in this territory.

Ethnographic descriptions confirm archaeological discoveries from the areas of present Ukraine, presented in details by Czepielew (1999). The objects under discussion are three boats excavated in 1966 from the Goryń River near the town of Orżew. The largest preserved was 13 m

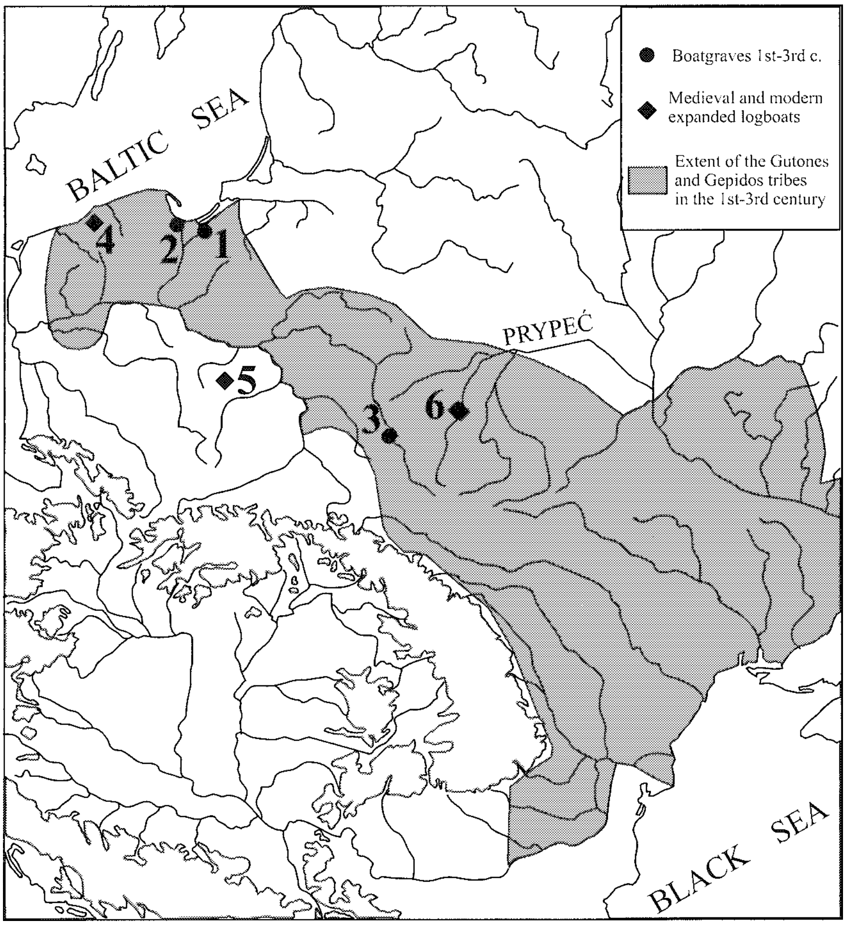
● Boatgraves 1st-3rd c.
◆ Medieval and modern expanded logboats
▨ Extent of the Gutones and Gepidos tribes in the 1st-3rd century
BALTIC SEA
PRYPEĆ
BLACK SEA
1
2
3
4
5
6

Fig. 27.6. Distribution map of the expanded logboats between the Baltic sea Black Sea. 1 – Weklice, 2- Ulkowy, 3- Masłomęcz, 4- Kazimierz Pomorski, 5- Sierzchów, 6- Orżew.

long, 2.6 m wide and only 80 cm high, while the thin boards thicken from 3 m to 7 m at the bottom. There used to be 9 oval ribs with rectangular section, fitted to the bottom and the boards with pine pegs. On the discovery, one might also notice a wooden plank 5 cm thick attached to the left board. The other two logboats differed with their sizes which were following: the first one was 11 m long, 90 cm wide and 50 cm high, while the smallest one was respectively 4.40 m, 48 cm and 30 cm. The conventional radiocarbon age of the Orżew I logboat was determined as 350 ± 90 BP (Ossowski, 1999).

In summarising this brief review of the latest research into expanded logboats from Poland, we may state that the boat graves from Weklice confirm the knowledge of the expansion technique on the southern coasts of the Baltic Sea in the first centuries AD (Fig. 27.5). The eldest so far identified expanded logboats in Poland are known from boat graves dated to 2nd and 3rd centuries AD, in the cemeteries of the Wielbark Culture at the mouth of the Vistula River. According to archaeological researches, this area served then as a centre of amber distribution. Special interest of the Roman Empire in the amber, of which fashionable decorations in 1st and 2nd centuries were made, led to a significant increase in amber trade. The profits from this exchange used to attract active newcomers from the basin of the Baltic Sea, merchants, sailors and craftsmen from Scandinavia, the Danish Islands and the Elbe River circle. The migration of Germanic tribes of the *Goths* and *Gepidos* (whose archaeological reflection lies in so called Wielbark Culture), from the southern coasts of the Baltic in the direction of the Black Sea (Salamon, 1975) might have given rise to diffusing the knowledge of expanded logboats construction in this area.

The abundance of raw material in the Middle Ages providing a wealth of raw materials for the production of water craft. The accurate dating of the remains of logboats from Poland indicates that 53 from 132 Polish logboats dated are of medieval origin. The studies carried out on the logboats so far recovered in Poland have demonstrated the diversity of logboat form used throughout the Middle Ages (Ossowski, 1999). Among the earliest of the medieval Slavonic logboats various types can be distinguished, depending on their intended use. Modified logboats come from this period, a time that witnessed an intensification of inland water transport (Ossowski, 2000). Only two examples of medieval expanded logboats can be connected with influences of others shipbuilding traditions. The possibilities that they are Scandinavian influences cannot be ruled out.

In the Middle Ages, this technique was applied while building oak logboats of considerable sizes, equipped with treenailed frames, additional strakes and caulked with moss. Subsequently, the boats being of interest to us were used on a mass scale in the area of the Prypeć River estuary, which is probably connected with the abundance of the adequate raw material in this region.

In 19th century, due to the lack of trunks for logboat and the occurrence of cheaper timber, expanded logboats disappeared on this territory and soon plank boats began prevailing in local boatbuilding.

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28. A New Look at the Utrecht Ship

Aleydis Van de Moortel

The Utrecht ship is well known among scholars of medieval northern European shipbuilding as the "banana-shaped" vessel from the Centraal Museum, which was excavated in 1930, but for a long time remained somewhat mysterious because of a lack of comprehensive archaeological documentation (Vlek, 1987). Even though widely recognized as a key find for the understanding of the development of northern European shipbuilding, the ship for many decades was known to the scholarly public only through simplified drawings and short descriptions. It had been found a few kilometers north of the medieval city of Utrecht, in an old bed of the River Vecht, which connected the Rhine with the Aelmere, the predecessor of the Zuyderzee (Fig. 28.1; de Groot, 1992: 26).

In 1987 a first detailed scientific study, by Robert Vlek, provided a full account of the many controversies surrounding this vessel, offering fresh insights and interpretations. However, lacking the means to conduct a full hull documentation, also this author produced only simplified drawings. Relying on new historical and archaeological evidence, he redated the ship to the early 11th century, thus dismissing the earlier proposed Roman or Carolingian dates. More recent dendrochronological analysis of the starboard wale, carried out by E. Jansma of the Dutch Archaeological Service, supports Vlek's dating. With the sapwood missing, the outermost ring was dated to AD 997 (Vlek, written comm. 1997).

In 1997, at Vlek's initiative, the Utrecht ship was included in the MARES project set up by Utrecht's Centraal Museum, the Danish National Museum, and Schloss Gottorf in Germany to improve the exhibition of this vessel and of the Nydam boat. The project was funded by a European Raphael grant. Work on the Utrecht ship was mostly carried out by people from various departments of the Danish National Museum. Members of the Conservation Department thoroughly cleaned an partially reconserved the hull. It was set on new and lighter frames of stainless steel by J. Nørlem and T. Thomasen – the latter of the Institute of Maritime Archaeology. A full documentation of the hull was carried out with a Total Station (a high-precision laser mapping system), supplemented with numerous hand measurements. Survey specialist K. Støttrup of the Danish State Antiquary's Archaeological Secretariat and architect C. Lemée of the

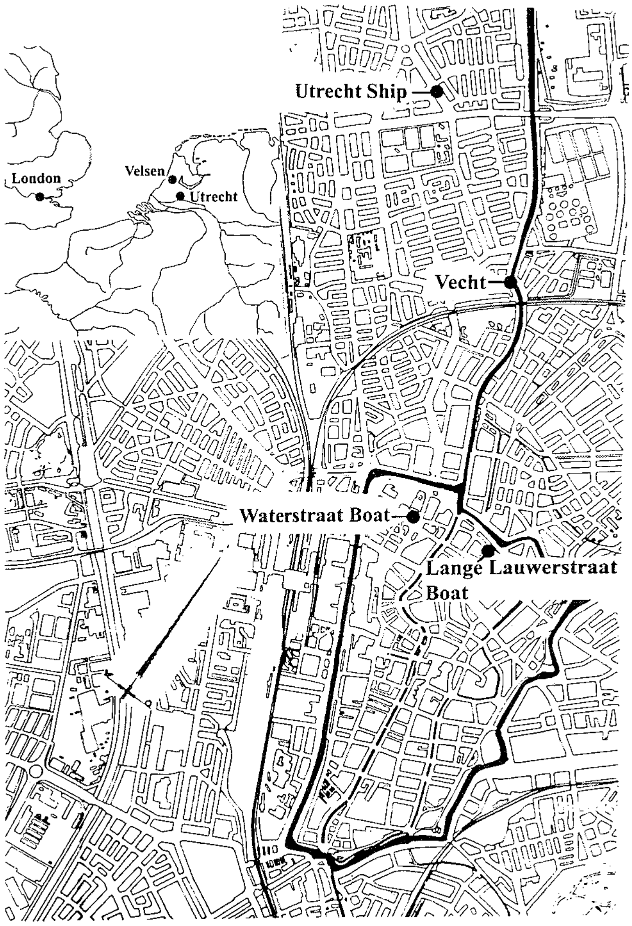

Fig. 28.1. Maps of Utrecht and the region of the southern North Sea, showing find spots of the five securely identified vessels of the Utrecht type (after Vlek 1987: fig. 1.1.1).

Centre for Maritime Archaeology (C.M.A.) handled the Total Station. L. Dokkedal and F. M. Hocker, of the C.M.A., as well as R. Paardekooper of the University of Leyden helped with hand measurements and final observations. The digitally obtained drawings were manually put into final form by Lemée, the present author, and Dokkedal.

As a result of the MARES project we are now able to propose a new reconstruction of the ship's original shape and interior fittings. Using the I-SHIP program, K. Jensen of the C.M.A. calculated its carrying capacity and sailing characteristics (for I-SHIP, see Jensen, 2000). These together with new historical and archaeological evidence published by Dutch scholars (de Groot, 1992; 1997; Van Vliet, 2000) enable us to better understand the ship's features in the historical context of early 11th century Utrecht. The various MARES reports can be read on-line (www.natmus.dk/nmf), and are being prepared for publication; drawings will be made available on the NAVIS web site (www.waterland.net/navis).

The great scientific value of the Utrecht ship lies in its peculiar construction. It is in fact a very large example of an extended logboat. Instead of a keel or a flat planked bottom, it has at its center a huge logboat or hollowed-out tree trunk, almost 13.80 m. long and 1.90 m. wide, and 0.04–0.06 m. thick, which has been extended by the addition of large strakes, halfround wales, halfround rubbing strakes, and extension boards (Fig. 28.2d). The overall preserved length of the hull is 17.45 m., its beam 3.85 m., and midship height 1.30 m. All hull parts, including the logboat, are made of oak *(Quercus* sp.*)* (Vlek, 1987:74–78).

Because of its logboat base the Utrecht ship often is considered to be a transitional craft between logboats and the fully plank-built boats of the later Middle Ages (Fliedner, 1969: 64; Crumlin-Pedersen, 1984: 243–245, fig. 122; Ellmers, 1984: 59, 61; Vlek, 1987: 48–57). Not everyone accepts its transitional role, however. Vlek, followed by other scholars, regards it instead as a terminal stage in the development of logboats – a product of a simple, outmoded technology without any connection to plank-built vessels (Vlek, 1987: 143–145; 1996: 86; Reinders, Oosting, 1989; Hutchinson, 1994: 12–13).

The present article deals primarily with a major question surrounding this logboat base: how was it shaped? The result of our recent research on this aspect and further investigations into this and comparable boatbuilding traditions support the idea of the Utrecht ship as a transitional craft and allow us to place it somewhat more firmly in the history of northern European shipbuilding.

Ever since the ship's discovery, scholars have been divided over the question of whether its logboat base was entirely carved into shape or whether it was expanded, that is, widened by artificially bending out the sides. The question is important, because expansion represents an advanced stage of logboat construction. It enlarges the logboat's capacity and makes it wider and more gracefully curving, thus improving its navigational qualities (Crumlin-Pedersen, 1989: 45–47). Moreover, as will be discussed below, expanded logboats can be developed into larger ships. Even though in recent years quite a number of archaeological oak logboats, ranging in date from Roman to modern times, have been claimed to have been expanded, many scholars still find it difficult to accept the feasibility of expanding oak logboats (Crumlin-Pedersen, 1991: 254, 261; Vlierman, 1996: 90; Ossowski, 1999: 162, 218–219, figs. 78, 80, 148).

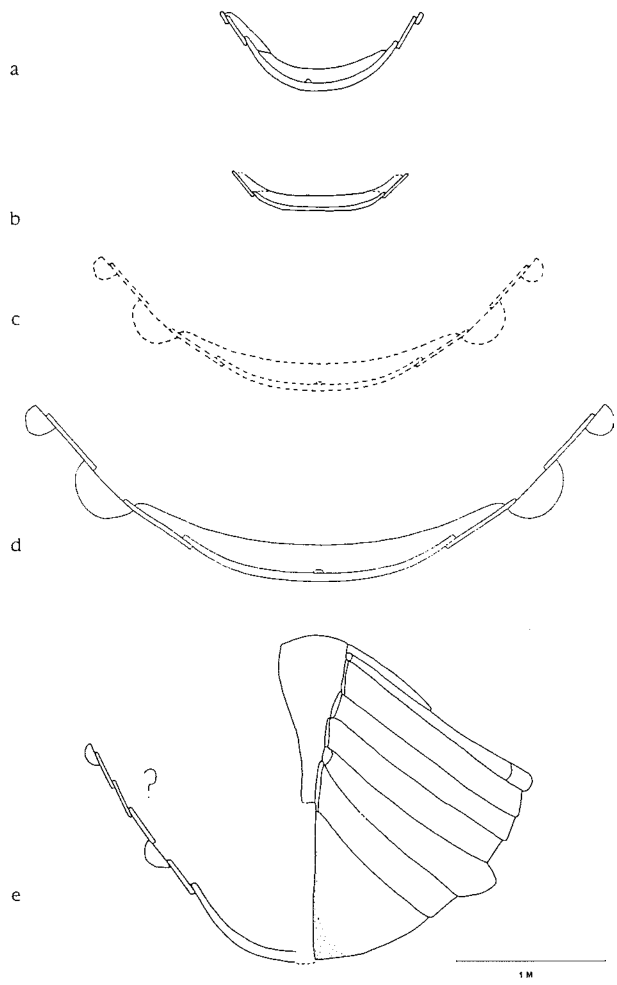

Fig. 28.2. Schematic cross sections of five Utrecht-type vessels, shown roughly to scale: a) Velsen boat (after de Weerd, 1987: fig. 12.5a; b) fragment Lange Lauwerstraat, Utrecht, section near bow or stern (after Vlierman, 1996: Fig. 61F); c) Waterstraat boat, hypothetical section equal to section of Utrecht ship at scale 3:4; d) Utrecht ship; e) Queenhithe ship, hypothetical reconstruction (after Goodburn, 2000: fig. 5B).

Arguments against expansion are the following:

- it seems very difficult, if not impossible, to expand an oak logoat because the oak would crack along its medullary rays (*i.e.*, the cells running from the tree surface to its heart) (de Vries Lentsch, written comm.

1930; Köster, 1930; van der Wijk, 1933: 30; Timmerman, 1956: 224; Vlek, 1987: 107–109; Gifford, 1993: 52);
- no ethnographic example of an expanded oak logboat is known (McGrail, 1978: 40);
- in the case of the Utrecht logboat, its very large size, perceived thickness, and spiral grain make it seem all the more impossible that it could have been expanded (see Vlek, 1987: 107);
- an early photo of the Utrecht logboat shows that the wood grain in a crack near the bow runs at an angle to the outboard surface of the logboat, which means that the logboat had been carved into shape at least at that location (Vlek, 1987: 107, pl. 5.1.2).

In the following, it is argued that the Utrecht ship's logboat was indeed expanded. Some arguments can be borrowed from a list of criteria gathered by O. Crumlin-Pedersen, who has argued for the expansion of this and other oak logboats (Crumlin-Pedersen, 1991: 254, 261; 1997: 27):

- oak can be expanded when it is freshly cut, before it dries and becomes hard and stiff; Gifford (1993) indeed successfully flattened a curved, circumferentially cut, piece of green oak with the use of hot water;
- indicative of expansion is that the Utrecht logboat has a parabolic cross section with curved sides, and graceful longitudinal curves without abrupt transitions;
- the logboat is quite thin in relation to its length and width, being only 0.04–0.06 m thick but almost 14 m long and 2 m wide. An early publication erroneously stated that the logboat was 0.10 m thick (van der Wijk, 1933: 30). Even though Vlek has corrected this mistake in his text, the error is still repeated in published cross sectional drawings and has reinforced the impression that expansion would not be feasible (Vlek, 1987: 107 *vs.* pls. 1.3.17, 6.2.4; Vlierman, 1996: fig. 61G in appendix 9). The correct thickness of the logboat is shown in Fig. 28.2d;
- another feature of expanded logboats is a great concern on the part of the builder to control wall thickness; in the Utrecht ship logboat this is reflected by the presence of many small plugged holes, which Vlek has interpreted as thickness gauges (Vlek, 1987: 109). When documenting the hull we found many more, previously hidden holes, including in the central part of the logboat, and estimate their original number to approach 300 (Fig. 28.3). The holes are arranged in rows as a rule spaced about 0.45 m apart;
- the floor timbers of the Utrecht ship are symmetrical about the longitudinal axis and are evenly distributed – yet another feature of expanded logboats. Many floor timbers cover the logboat base but do not continue over the strakes, which suggests that their primary purpose was related to the logboat;
- three of Crumlin-Pedersen's criteria were not usable on the Utrecht ship logboat: a presence of multiple small cracks on the interior surface as a result of expansion or a presence of charring by fire used for expansion could not be established, because the hull had been covered in the 1930s by a thick creosote and linseed oil coating that had bonded with the surface and could no longer be removed; we neither could check whether the large cracks visible in the logboat were wider inboard than outboard (see McGrail, 1978: 40), because shrinking had distorted the shape of those cracks.

Even though the Utrecht ship's logboat showed several characteristics indicative of expansion, these seemed not quite sufficient, in view of its exorbitant size and twisted grain. To take things further, since we could not study the hull surface, we decided to direct our attention to the internal structure of the wood, and more precisely to its medullary rays and longitudinal cells. This part of the study was done in close consultation with J. Bill.

It was to be expected that, if simply carved, the logboat would have the medullary rays and longitudinal cells of a normal oak tree trunk, showing a somewhat larger tree diameter at the bottom of the trunk, corresponding to the bow part of the logboat, and tapering to the top (Fig.

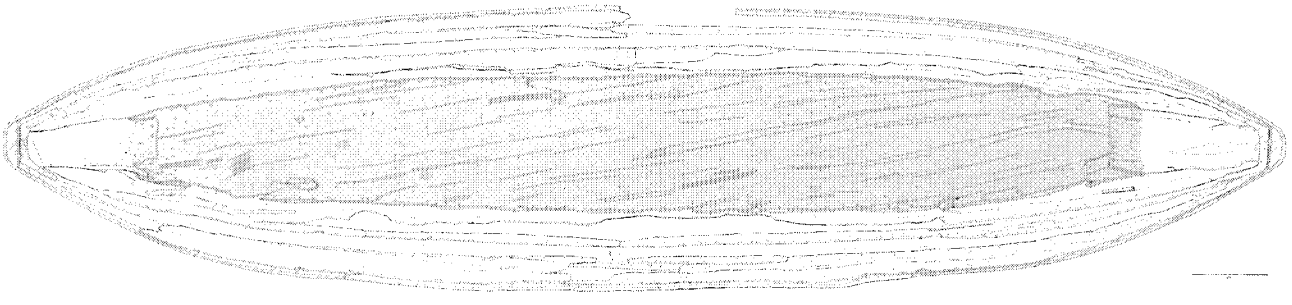

Fig. 28.3. Plan view of the Utrecht ship without frames. The logboat base is shaded light gray. Hatched parts are modern (drawing: C. Lemée, A. Van de Moortel, inked by L. Dokkedal.

28.4a). If, in contrast, the logboat had been expanded, we would expect the medullary rays amidships to converge at a much higher point than the original heart of the tree, and the longitudinal cells to follow this distortion, suggesting an unnatural tree trunk shape which was smaller at the bottom and the top (Figs. 28.4b and 28.5).

The easiest way of studying the orientation of the medullary rays amidships and at the logboat extremities would have been to cut the logboat into pieces. However, our conservators did not allow this because it would have weakened too much the logboat's strength, endangering its preservation. Instead, we drilled 25 core samples in the logboat: two transverse rows in the bow, one row amidships, and one in the stern, and plotted the orientation of their medullary rays (Fig. 28.6).

We found that the medullary rays amidships converge at roughly 1.45 m from the outboard surface of the logboat, which does not include sapwood. This means that, if not expanded, the original heart of the tree trunk would have been located here and the trunk would have had the enormous diameter of more than 3 m at a height of about 7 m above the ground. This is perhaps not impossible, but it is highly unlikely that such a huge oak tree has ever existed with still a sound inner texture allowing the carving of the logboat extremities (see McGrail, 1978: 121).

There is more evidence supporting expansion. In the bow and stern, the convergence points of the medullary rays were located 0.20 and 0.40 m. lower, respectively. This could suggest that the hypothetical tree trunk diameter was smaller in the bow and stern, and thus an expansion of the logboat amidships. However, it could also mean that the parent tree trunk had been crooked with a downward curving heart line; thus the lower convergence points in the bow and stern could be explained without resorting to expansion. What settled this question was the curvature of the longitudinal wood cells of the logboat, which did not curve downwards with the hypothetical heart line of the tree, but but upwards, in the opposite direction (Fig. 28.7). Such an opposition in the two curvatures is unnatural and can only be explained as the result of expansion (see Fig. 28.5).

Thus we believe we now have solid evidence for the expansion of the largest oak logboat known to date. The result demonstrates that the builder of the Utrecht ship

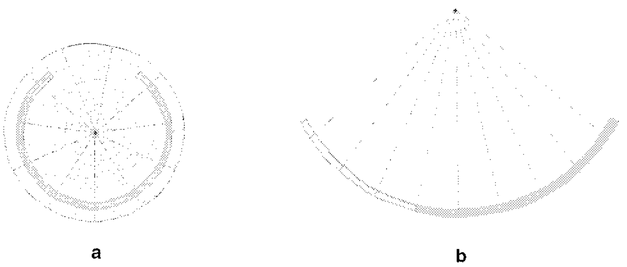

Fig. 28.4. Cross sections of a hypothetical logboat: a) not expanded; b) expanded.

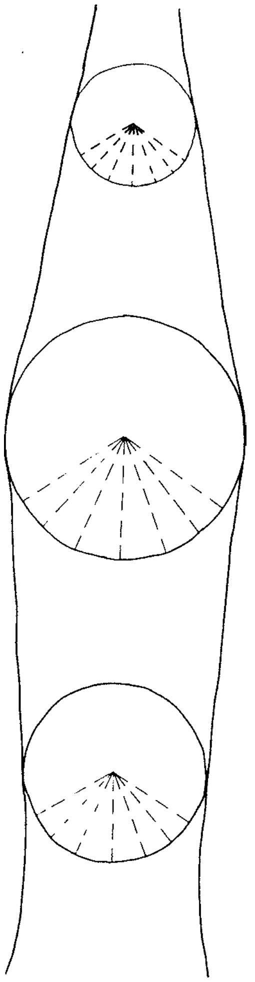

Fig. 28.5. Schematic view of an expanded hypothetical tree trunk, with convergence plots of medullary rays.

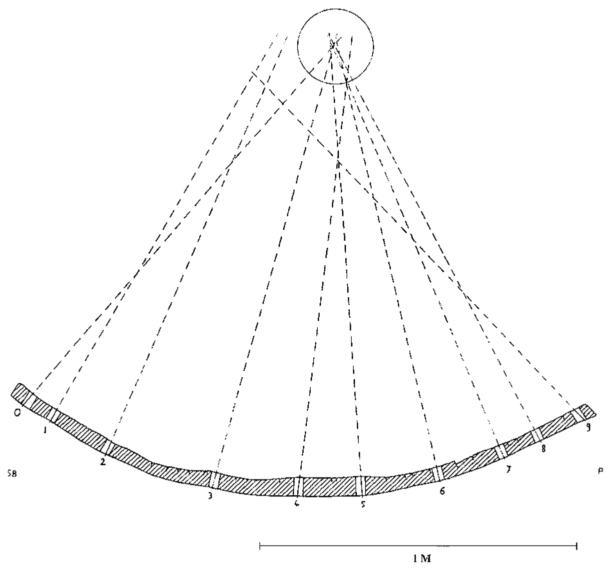

Fig. 28.6. Row of ten core samples taken amidships from the logboat base of the Utrecht ship. Dashed lines show the extension of the medullary rays observed in the drill holes. They converge at about 1.45 m. from the inboard surface of the logboat.

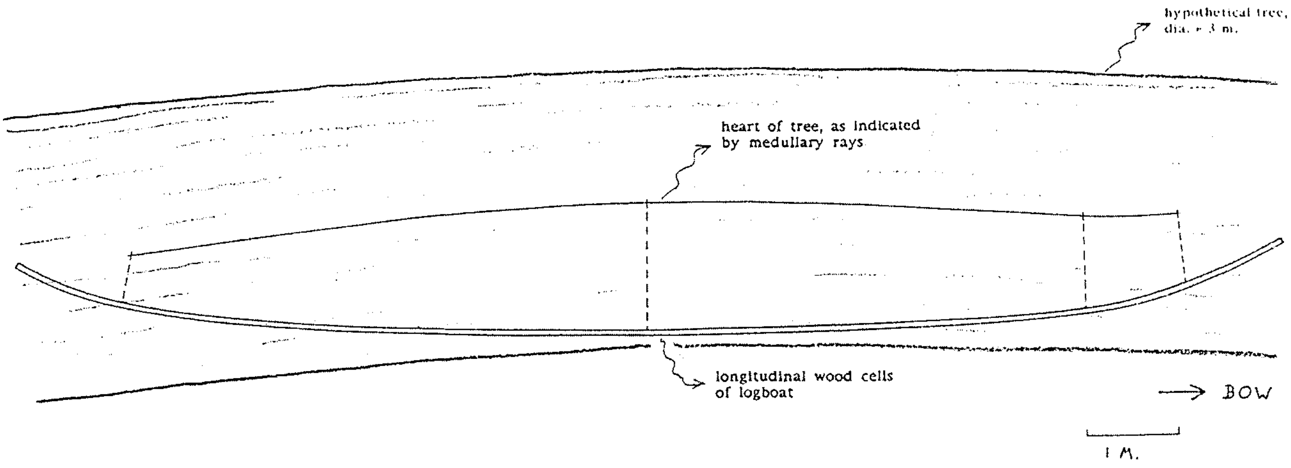
hypothetical tree,
dia. ≈ 3 m.
heart of tree, as indicated by medullary rays
longitudinal wood cells of logboat
BOW
1 M.

Fig. 28.7. Longitudinal section of the Utrecht ship logboat superimposed on the hypothetical parent tree with a diameter of 3 m (assuming that no expansion had taken place). The longitudinal wood cells follow the slightly upward curvature of the logboat over most of its length, whereas the hypothetical heart line of the tree, as indicated by the medullary rays, curves downward. The opposing curvature of wood cells and heartline is unnatural and shows that expansion did take place.

had reached a high level of technological sophistication and a close familiarity with oak timber. Even now we do not quite comprehend how one can expand a logboat of this size with a twisted grain. A difficult moment must have come after expansion, when the green oak dried and became "bone" oak; presumably the large cracks seen in the logboat appeared at that time. The unusual number of heavy, close-set floor timbers covering only the logboat base of the Utrecht ship may well have been brought in when the wood was still green, to counteract drying pressures and hold the logboat firmly together.

Expanded logboats such as the Utrecht ship base should not be seen as simple hollowed-out logs produced by a rather primitive, outmoded technology. Rather, we should think of the Utrecht ship logboat as a huge, thin wooden shell carefully extracted from the trunk, and bent and stretched into the desired shape to form the solid bottom of a ship's hull (see Crumlin-Pedersen, 1991: 255). In other words, it is the product of sophisticated woodworking skills, truly reflective of a building tradition at an intermediary stage between logboat construction and the production of fully plank-built vessels.

Understanding the Utrecht ship in this way helps us to reevaluate its position and significance in the development of medieval northern European shipbuiding. Even though related to the expanded logboat tradition of the Baltic region and the Anglo-Saxon area of Britain (Crumlin-Pedersen, 1991: 259), it belongs to a separate boatbuilding tradition, set apart by a preference for heavy scantling and an idiosyncratic caulking technique. We know to date 5 or 6 wrecks with similar characteristics, which can be assigned to P. Marsden's Utrecht type (Figs. 28.1 and 28.2; Marsden, 1976: 49). Three come from Utrecht itself: the Utrecht ship, the Waterstraat boat (Hoekstra, 1975; Vlek, 1987: 89–103), and a fragmentary example from the Lange Lauwerstraat (Vlierman, 1996: 88–91). A fourth wreck was found at Velsen, in Noord-Holland (Vlek, 1987: 140–143; de Weerd, 1987); and a fifth example consist of highly fragmentary remains from the Queenhithe inlet in the Bull Wharf area of the harbor of London (Goodburn, 2000). An unpublished find from lot Pz 49 at Zeewolde, in the former Zuyderzee, reportedly may belong to the Utrecht type, but this needs verification (Vlierman, 1996: 91). To judge from their find spots and the origin of the wood of two of the vessels, this boatbuilding tradition most likely was located in the Lower Rhine area. Dendro-analyses have shown that the Utrecht ship wale derives from West Holland (Vlek, written comm. 1997), and the London fragments from the area of the Low Countries (Goodburn, 2000: 223).

The five securely identified vessels of the Utrecht type are consistent in date, ranging from the late 10th through the 12th centuries. They have as their base an expanded oak logboat (de Weerd, 1987: 266; Vlierman, 1996: 90 and fig. 60: note that the logboat fragment of the Lange Lauwerstraat appears to have curled back towards its original shape after having lost its internal stiffeners – an indication of former expansion). This logboat base was extended with one or more heavy strakes and, if deemed necessary, large wales and extension boards. Most commonly used wood types are oak and ash; planks have been joined by treenails, usually of willow or poplar, wedged with oak plugs (for other wood types on the Velsen boat, see de Weerd, 1987: 274). All have moss caulking held by mosslaths and iron staples (Dutch *sintelnagels*), belonging to Vlierman's type A (Vlierman, 1997: fig. 3). Tool marks found on the Utrecht and Queenhithe ships reveal the use of the axe and adze, but not of the saw (Vlek, 1987: 9; Goodburn, 2000: 221), even though Goodburn does not exclude the possibility that the planks from London had been sawn.

Thus we are dealing with a coherent expanded logboat tradition on the Lower Rhine capable of producing small river-going craft (the boat from Velsen), as well as larger river vessels (the three finds from Utrecht), and seagoing ships such as the Queenhithe vessel which, having been built on the continent, obviously had crossed the sea. That extended or expanded logboats can be seaworthy should no longer come as a surprise, since such vessels have been recorded elsewhere in the world (Crumlin-Pedersen, 1988: 538-542; 1989: 41, 44–47).

A most interesting ethnographic parallel for the Utrecht type is provided by the Dayak logboat tradition of southern Borneo, of which a study was recently published by E. Petersen (2000) for the Roskilde Viking Ship Museum. There, still to this day, in waters comparable to those of the Middle and Lower Rhine in the Middle Ages (including the dangerous rapids between Coblenz and Mainz: Lebecq, 1983: 218–222) , expanded logboats are made and used as simple fishing craft, or built up to larger boats which can reach the size of car ferries. Until recently, even seagoing sailing vessels were produced from such expanded and extended logboats. A comparable expanded logboat tradition has been reported from the Caribbean Sea (Crumlin-Pedersen, 1989: 45–47). To all appearances, the vessels of the Utrecht type belonged to a similarly versatile and well-functioning expanded logboat tradition capable of producing various riverine and seagoing craft.

This brings us to another major question surrounding the Utrecht type vessels: were they or were they not the forerunners of the hulk? Hulks are late medieval trading vessels known from texts from the late 10th century on (Fliedner, 1969: 54). They have been identified in ship iconography as vessels with extremely rounded hulls, because of the late 13th century seal from New Shoreham which shows such a ship and refers to it as a hulk (Fliedner, 1969: 55, fig. 1). Similar ship images, often thought to represent forerunners of hulks or hulks themselves, are seen on 9th century Carolingian coins and on later medieval representations from the early 12th century on (for example, Crumlin-Pedersen, 1965: 142; Fliedner, 1969: figs. 2, 3, 5–7; Vlek, 1987: 85–87; Hutchinson, 1994: frontispiece, figs. 1.4–1.6, 2.1b, 3.2, 3.5, 5.3; Greenhill, 2000). In Crumlin-Pedersen's view, the Utrecht ship, the Carolingian vessels, and later medieval hulks are representatives of the same building concept, and form one of the four basic ship types of medieval northern European ship construction (Crumlin-Pedersen, 1984: 242–244).

There are some arguments supporting the identification of Utrecht-type vessels with hulks. Several scholars remarked that the roundedness of the Utrecht ship profile and its sweeping plank runs resemble those of hulk depictions, and have therefore suggested that the Utrecht ship was the forerunner of the hulk or an early form of this ship type (Crumlin-Pedersen, 1965: 142; Fliedner, 1969: 64; Ellmers, 1984: 59; 1985: 67). Moreover, the word hulk could derive from the Germanic root *holh,* and mean something like "hollowed out" (Fliedner, 1969: 56); thus it may possibly refer to a logboat bottom. Finally, the earliest English text, of *circa* 991–1002 AD, using the term hulk (*"hulcus"*) refers to the very area of the London harbor where the roughly contemporary Queenhithe ship fragments were found (Goodburn, 2000: 220). None of these arguments, however seductive, are totally convincing, however (see Vlek, 1987: 143–145).

There is no time here to go into a detailed analysis of the question, and I feel such exercise remains hypothetical until clear, undisputed wrecks of hulks are found. I will just end here by saying that our new understanding of the *technological sophistication, versatility, and seaworthiness* of expanded logboats of the Utrecht type brings them considerably closer to the seagoing late-medieval hulks, and invalidates the argument that Utrecht-type vessels were just simple inland craft without a future. One can surmise that the limitations imposed by tree size, and the eventual exhaustion of large oak trees needed for the largest of these vessels would have prompted medieval shipbuilders at some point to make the transition from a rounded ship's bottom made of a single wooden shell to one built entirely of planks.

Acknowledgements

It is a great pleasure to acknowledge the help and advice given by many people in the course of this study. I thank O. Crumlin-Pedersen and J. Bill for offering me this project and for their close cooperation throughout. The warm welcome and ready help which we received from the staff of the Utrecht Centraal Museum, and in particular R. de Bruin and F. Pietersen, made our work all the more pleasurable. Valuable information and bibliographical references were given by R. de Bruin, R. Vlek, H. de Groot (municipal archaeologist of Utrecht), K. van Vliet (municipal archives, Utrecht), and K. Vlierman (N.I.S.A.). V. Vliet is especially thanked for allowing me to see his unpublished manuscript for a new publication on the Medieval history of Utrecht. Any inadequacies remaining in the present report are entirely mine.

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29. Investigation of Traditional Boatbuilding for the Reconstruction of Medieval Russian Boats

Petr Sorokin

Archaeological finds of medieval boats in the historical area of Russia are very rare. They are mostly boat parts and details in archaeological layers of towns, which had been re-used in another function, or were ready for reuse. Before we can reconstruct these fragmentary finds of medieval boats, we must first investigate different sources of traditional boatbuilding (ethnography): old boats and information about them; and iconographical representations; and also linguistically materials: traditional names of boats and their details.

The natural and economic conditions of medieval Russia: the shallows and rapids of the rivers, the remoteness of ports from the sea coast, contributed to the primary spreading of the types of craft, small and middle size, which were built on a dugout base, and flat-bottomed plank boats which were able to cope with different navigation conditions – in rivers, lakes and sometimes coastal seas. These types of boat could overcome obstacles in water-ways and were easy to make.

The boats with a dugout base were used for coastal seagoing into modern time. They had from one to four additional side planks. The shape of the plank boats, during the process of evolution, became more streamlined, therefore these boats could be used for both sea and lake navigation. The northern types of seagoing boat of the late Middle Ages and the post-medieval period had planking connected with the spreading of sewing technique of local tradition. All seagoing boats were middle sized – about 12–18 m long – and had half decks, a cabin, and two masts with square or sprit sails, and also oars.

The rich forest resources of Russia, the long distances involved and other transport difficulties resulted in the use of flat-bottomed cargo boats shaped like a container from the 18th to the beginning of the 20th century. In those days wooden materials from boats were re-used in the building of houses, bridges and other construction. This tradition of re-using boats parts in buildings and roads has been found in medieval archaeological layers (Fig. 29.1). Therefore it was not necessary to build such boats to high-quality. These circumstances determined the preservation of traditional boatbuilding technology.

On the other hand, the international overseas contacts in the Baltic region promoted the spreading of new technological ideas in shipbuilding. In the north-western Russian boatbuilding tradition can be traced a marked

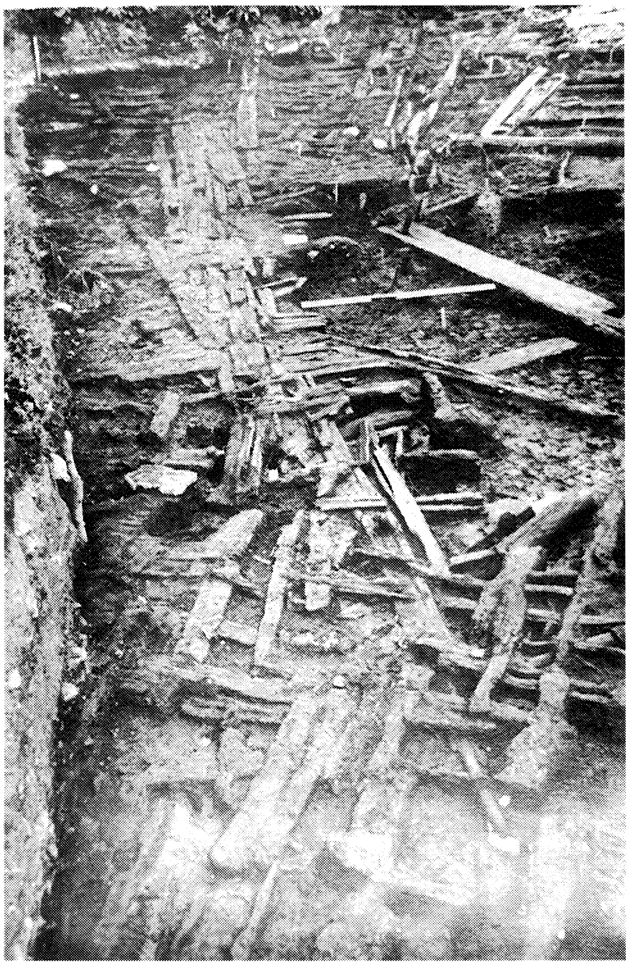

Fig 29.1. Parts of ferry-boats re-used in the construction of a late 9th century road in Staraya Ladoga (photo: V.I.Ravdonicas).

similarity to contemporary Scandinavian and Hanse towns shipbuilding technology. At the same time some original features can be distinguished.

After the gradual colonisation of the shores of the inner water-ways, during the late Middle Ages, the forward bases of Russian craft were transferred from the far districts of the region to the sea coasts – to new settlements on the lower parts of the river-system. This was an important prerequisite to the development of Russian seafaring and shipbuilding.

Peter the Great started the project of modern shipbuilding in Russia at the beginning of the 18th century. He invited many masters from European countries to realise his plans. To implant new technology in Russia, local traditional boats were forbidden by a special law. This practice continued until the early 19th century. But in spite of that, old traditions of building small and medium-sized craft existed to modern times, in the periphery of the country.

On the basis of the available archaeological material from medieval north-western Russia, we can admit as certain the existence of three main constructional types of craft: keel boats with clinker planking, flat-bottomed ferry-boats with flush-laid planking and log boats and craft with a dugout base (Sorokin, 2000).

The main types of Russian craft in the Viking age and medieval period can be correlated with traditional Russian boats types of the 18th to the beginning of the 20th century. Elements of medieval boatbuilding traditions continued in some parts of Russia (mainly in the northern region), Byelorussia and Ukraine (mainly in the Poles'e region) until the present day. Information about old boat building traditions can be documented by archaic types of boat and in the old technological details of new boats. There are also old people who remember these traditions or the remains of old boats.

Interesting information about traditional Russian boats and ships is found in ethnographical archives and in special publications of 19th and the beginning of the 20th centuries. In the middle 19th century, a book about traditional boatbuilding on the White Sea and in the Volga region was published by naval officer P. Bogoslovski. It includes detailed information and representations of different types of boat (Bogoslovski, 1859) (Fig. 29.2).

It is very important to document traditional boatbuilding because it is disappearing very quickly at the present day. Field research in the north-western region of Russia let us document several variants of logboats, traditional plank boats for lake use, and also some technological methods: the use of iron cramps for fastening caulking, which is known also from archaeological finds. Sewing boat-planking and other techniques used in medieval Russian boatbuilding are not now used in the European part of Russia since the middle of the last century, but some people remember them. Iron rivets – evidence of Scandinavian clinker boats of Viking age are not known in traditional boatbuilding technology.

The manufacture of expanded logboats is known only in the northern parts of the Russian territory, including Byelorussia. In southern Russia simple logboats were built. Most old finds of expanded logboats come from Novgorod 10th to 15th century (Sorokin, 1997: 83–84; Dubrovin, 2000: 70–77).

In north-west Russia until recently, the tradition of manufacturing logboats was undertaken on the small rivers, far from brisk waterways where more advanced boats were used. Logboats with extended side planking were produced mainly from aspen. There were two basic

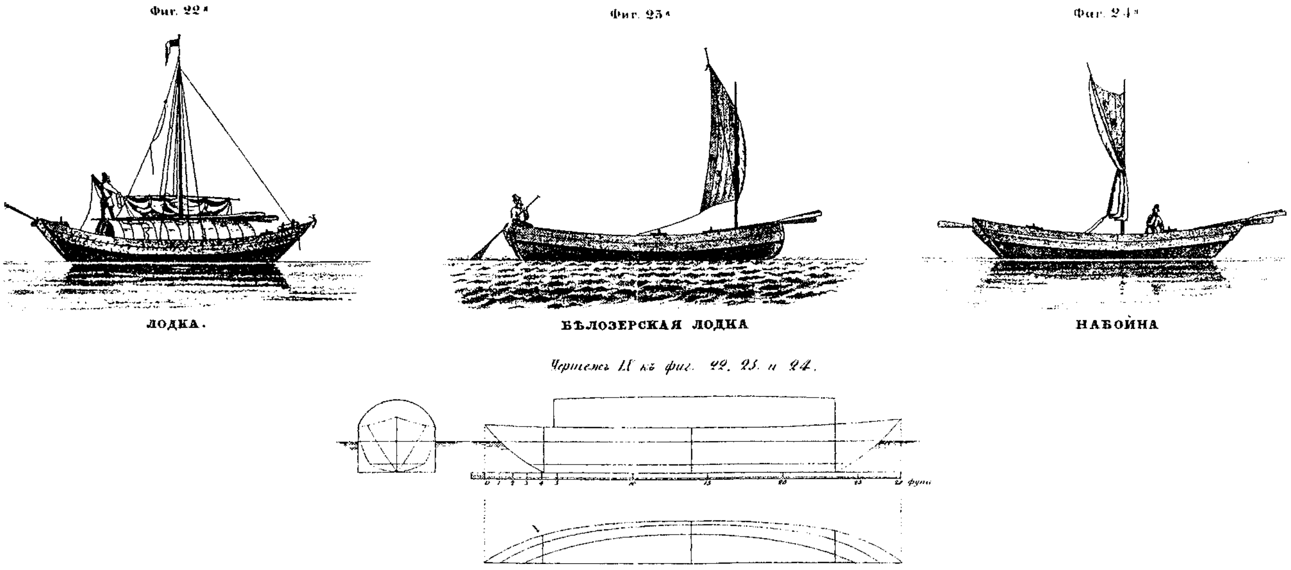
Фиг. 22.
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Fig 29.2. Different types of logboat in the Volga basin (drawing: P.Bogoslovski).

ways of expanding a tree: 1. above fire, 2. by the help of hot water in the sun. Sometimes, in addition, wedges were used to give the necessary form.

After felling the log with the help of an axe, saws were used to shape it externally. Then the log was hollowed out until the thickness of walls was about 2 -3 cm. After removing the bark and hollowing the inside of the tree, holes are made in the external side of the hull, using a special tool to a diameter 0.1 – 0.5 cm and a depth of 1 cm (Fig. 29.3). These holes are subsequently blocked with birch nails with the painted end – "storojki". They serve to prevent holing the boat during the final hollowing and also to ensure a constant thickness of sides and bottom: this is important at its thermal processing. It is necessary to note that, before detection of this technology in Russian ethnographic traditions, archaeological finds of parts of the logboats with "storojki" were interpreted as traces of double planking (Aleshcovski, 1969).

During hollowing cleats are left on the inside of the boat. Steam is made from fire wood above hot coals. During the processing of a boat, it is rotated to ensure uniform steam from different directions. Then the flexible rods are inserted into it to expand its hull (Fig. 29.4). After the width becomes sufficient, the frames made of a root part of a fir-tree and curved branches are established on the cleats inside the hull. These frames fix the shape of

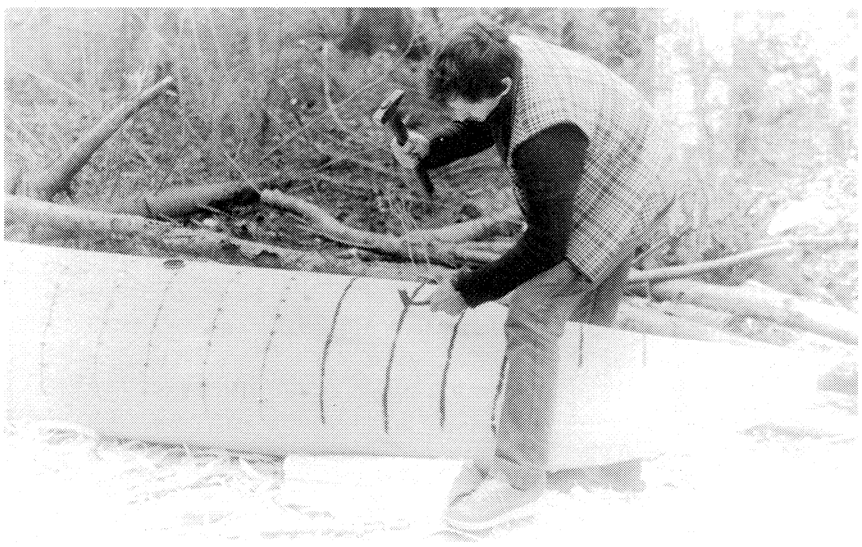

Fig 29.3. Boring holes in the hull of logboats to receive birch nails – indicators of thickness.

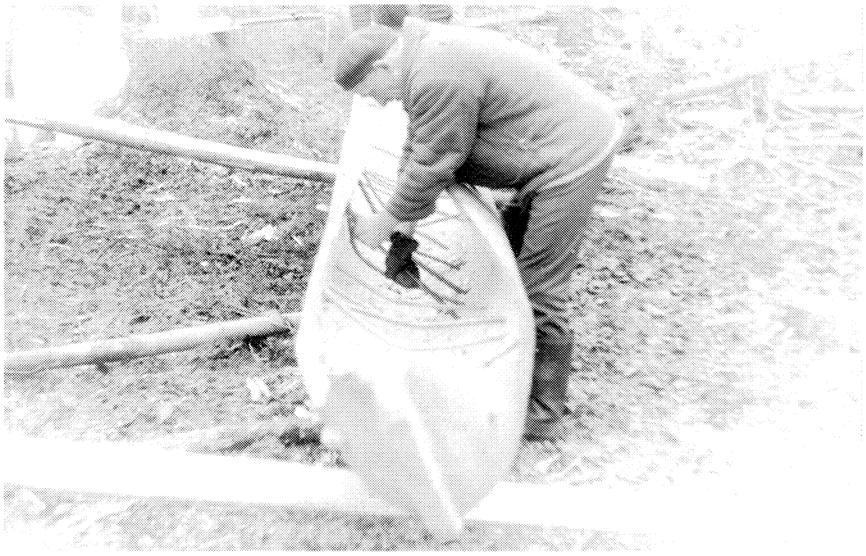

Fig 29.4. Inserting flexible rods into the hull of logboats.

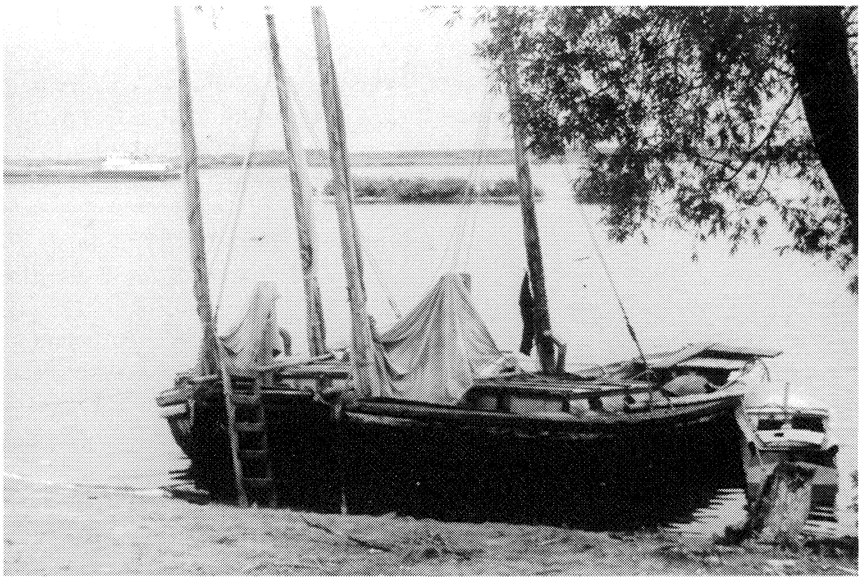

Fig 29.5. Traditional boat Soima on Lake Ilmen.

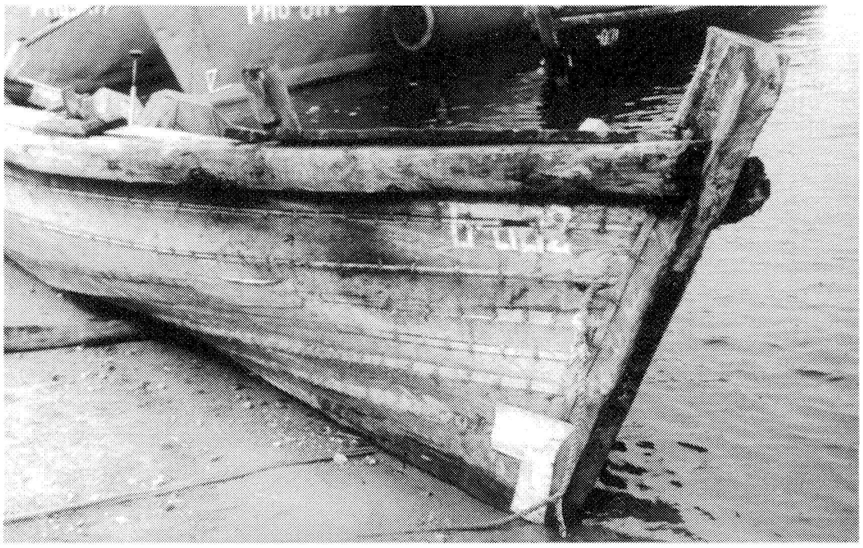

Fig 29.6. Caulking a plank hull using pressure from a rod with iron cramps.

a boat from within and do not allow it to be compressed after cooling. In the other variant of expansion of logboats water is poured into the hull which is then left to bent in the sun. The expansion in this case occurs as a result of heating water.

From traditional plank boats for lake navigation and fishing two types were still in use until recently: Ladja on lake Ladoga and Soima on lake Ilmen in the north-west region of Russia. Both were keel boats with a rounded bottom section with the planking in clinker: they were used for fishing. Ladoga Ladja reached about 8 – 10 m in length and about 2 – 2.5 m in width; they had one mast with a square or sprit sail. Ilmen Soima – reached 12 – 18 m in length and about 2.5 – 3 m in width and were equipped with two masts with sprit sails. From historical sources we know that Soimas were sailed from north-western Russia to Stockholm in the 17th century (Fig. 29.5).

The ancient system of caulking a plank hull using pressure from a rod with iron cramps continued to be used on Soimas (Fig. 29.6). This technological innovation occured in northwest Russia in the 12th century with the beginning of active trade between Novgorod and the Hanse towns. The method probably came from Germany and it continued to be used in Russian traditional ship-building down to the end of the 20th century. Boats with a similar system of hermetic sealing of the seams were known in the basin of Tchudskoe Ilmen Lakes. The study of boats and the technological elements of traditional boatbuilding allows us to find answers to many questions concerning medieval boatbuilding.

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30. Wooden Shipbuilding on Lake Constance before 1900

Dietrich Hakelberg

The pre-Alpine lakes – such as Lake Geneva, Lake Zurich, Lake Constance and the smaller Lake Walenstadt – played an important role in transalpine transportation from Roman times onwards. Before the earliest railways, it was not only easier but far more economic to use waterways for transport of goods and people, particularly in view of the poor road conditions. Many roads crossing the pre-Alpine foreland and the trails coming down the river valleys from the Alpine passes were linked by these lakes, which were thus used for the distribution of transalpine and regional traffic (see Eitel, 1996). Ships were consequently a significant means of transportation on these inland waters. Lake Constance, bordering today on Switzerland, Austria and Germany, was always a focal point of political interests and was situated in the center of the bishopric of Konstanz. The firm grip on shipping by the early medieval monasteries St. Gallen and Reichenau (the latter just recently added to the UNESCO World Heritage list), the prospering trade of the medieval towns Konstanz and Lindau, late-medieval global trade and seafaring and finally post-medieval industrialization suggest that changing political and economic factors affected the organization of shipping on Lake Constance. Was there interaction between economical and technological changes and did they have an impact on shipbuilding? A study of the long-lived tradition of building wooden flat-bottomed sailing-vessels is highly dependent upon archaeology due to a paucity of other sources.

After having analyzed the well-known flat-bottomed Roman shipwrecks from Lake Neuchâtel, Béat Arnold was the first to point out the presence of comparable medieval and post-medieval shipwrecks in the lakes north of the Alps (Arnold, 1976; 1985; 1992: 102–107). Recent archaeological finds shed light on the keel-less *bottom-based* construction and on the development of distinctive hull-designs on medieval and post-medieval Lake Constance.

In the 19th century, the Middle Ages were still omnipresent in the everyday life of the rural population. Learned people of the time were aware that the history of contemporary ships and shipping on Lake Constance was very old. The Swiss historiographer Georg Leonhard Hartmann wrote in 1808: *"The ships of Lake Constance are very simply built and differ from one another only in size. ... It is quite remarkable that shipbuilding on this lake has not changed for centuries and that the various attempts at using ships of other designs have always failed"* (Hartmann, 1808: 83).

Lädinen and *Segner*, both fitted with a trapezoidal square sail, were the two sizes of traditional flat-bottomed vessels on Lake Constance (Leidenfrost, 1975; Bloesch, 1988). They had differing load capacities, which both seem to have increased gradually starting in the 17th century (Leidenfrost, 1975: 23–35). The *Lädinen*, which reached a capacity of up to 150 tons toward the end of the 18th century, apparently vanished already in the first decade of the 19th century (Schwab, 1840: 23). The *Segner* was the smaller of the two types; it loaded *ca.* 44 tons and remained in use until about 1910. Throughout the 19th century, this vessel took part in the hard everyday life of people, who still lived under social and technological circumstances that had not changed much since medieval times (Fig. 30.1). Even though the effects of the Enlightenment had made themselves be felt on the economic conditions on land, they did not have an impact on equally important economic factors like the technical development of shipping on Lake Constance. As late as 1889 the newspaper *Schwäbische Kronik* (Swabian Chronicle), in an article entitled "The sailing ships on Lake Constance" (Die Segelschiffahrt auf dem Bodensee), remarked upon the *"extremely poor knowledge of sailing, which results in the rigging and sail being absolutely insufficient"*. Sailing windward by tacking would be inconceivable, *"until the construction of the sailing vessels, in particular the rigging and the cut of the sails has been improved. It would be a great economic gain if sailing on Lake Constance could thus be generally promoted"*. The shipwrights and shipmen, however, were very conservative, and thus retained the construction techniques that had been handed down by their forefathers. The shipmen were still organized in guilds and rejected the introduction,

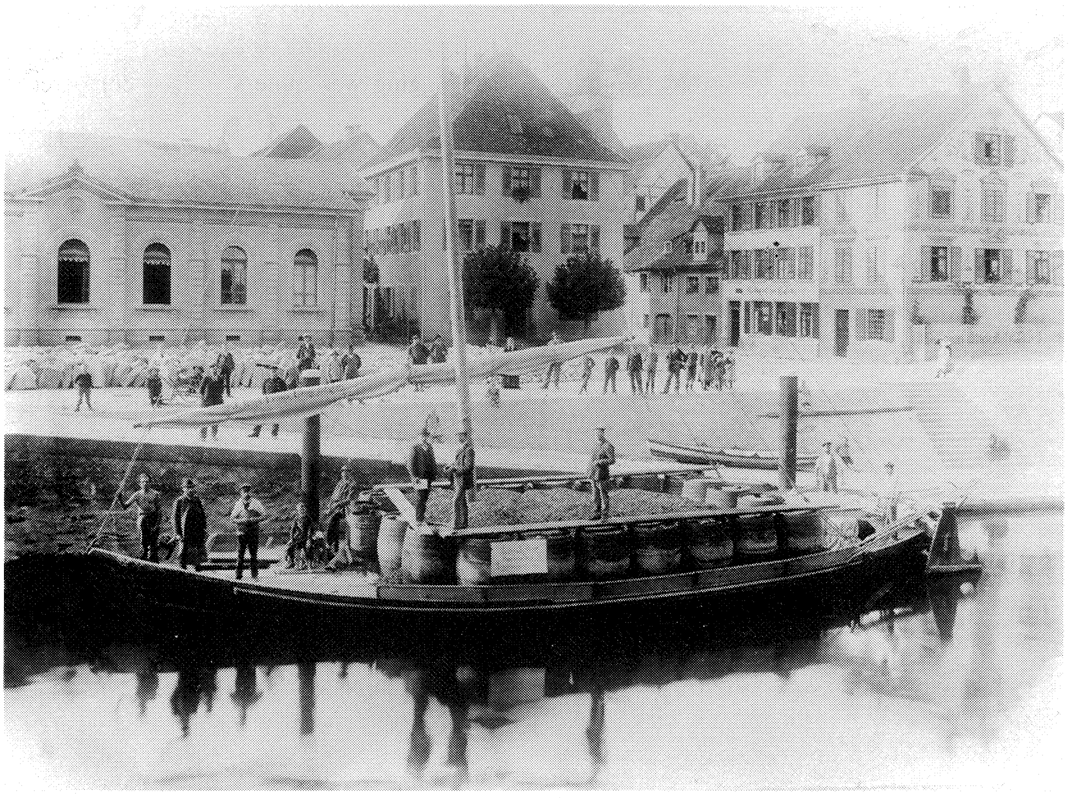


Fig. 30.1. A Segner *in the harbour at Überlingen, Lake Constance,* circa *1903 (courtesy of Siegfried Lauterwasser, Überlingen).*

beginning 1824, of the steam engine to Lake Constance, which was however promoted by the progressive middle class (Siefken, 1978).

A "long Middle Ages" in the development of wooden shipbuilding on Lake Constance is reflected by various pictorial sources of the 15th to 19th centuries. Written sources do not supply any information about medieval shipbuilding, and archival records of the post Middle Ages provide only little information on ship dimensions. Master moulds or the like are not extant, and it is also very likely that drawings were never made. Some technical details can be ascertained from a few medieval and post-medieval paintings, others from early photographs. Exploring the technology and development of wooden shipbuilding on Lake Constance until the 19th century proves to be a real archaeological task.

Archaeological research on ships and shipping on Lake Constance was initiated by the discovery of a shipwreck in the shallow water zone at the Kippenhorn, a spit near the village of Immenstaad (Hakelberg, 1996). Archival sources and archaeological evidence of jetties testify to the presence of a landing place in the vicinity of the site, which was still in use in the 19th century. The shipwreck was dated by means of dendrochronology to the second quarter of the 14th century and gave first insights into medieval shipbuilding on Lake Constance. The wreck, still some 18 m in length, was what remained of a flat-bottomed sailing vessel made of oak (Fig. 30.2).

The flat bottom – the fundamental feature of the bottom-based construction (see Rieth, 1981) – was built in three sections: the midship, built employing two chine strakes bearing an L-shaped rectangular profile and carved from two single oak logs, 11.60 m and 12.80 m long respectively; a sloping bow tapering forward, 7 m in length, and made up of broad planks of up to 70 cm in width; and the sloping non-tapering stern.

The bottom planks of both sloping bow and stern section were rabbetted and pinned to the horizontal midship bottom planking. The side planking overlapped the vertical side of the transition strake and was fastened with treenails, all wedged from in- and outboard. The side-planking extended beyond the edges of the sloping bottom fore and aft, where it was also fastened with treenails. The vertical side-planking apparently consisted of only one very broad strake, assembled of shorter planks which were hook scarfed to cope with the lengthwise tensile forces. Side-planking therefore guaranteed the sturdiness of the three portions of the ship's flat bottom (Fig. 30.4). Apparently due to a shortage of timber, there are many patches and filling pieces.

Bottom-based construction employing chine-strakes and vertical side planking resulted in a box-like hull form

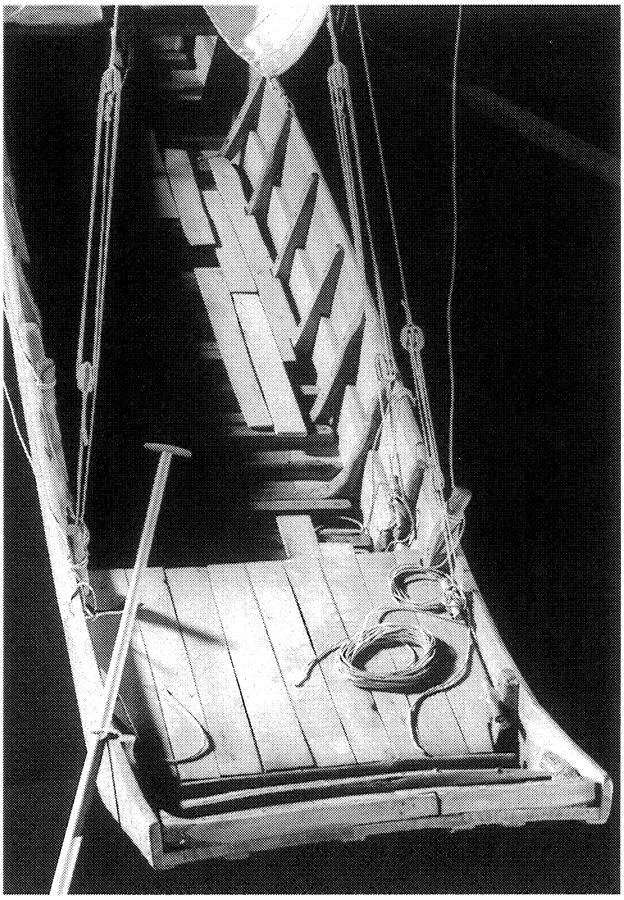


Fig. 30.2. The Immenstaad *vessel (1325–1350) reconstructed in 1:10 scale (model: author; photo: M. Schreiner, Archäologisches Landesmuseum Konstanz).*

with a slightly asymetrical polygonal ground plan. The highest preserved frame suggests a midship height of *ca.* 1.10 m, whereas the bottom of the stern and bow rise to a height of *ca.* 2 m. Frames were not installed until the plank shell had been completed. The frames were made of rectangular oak branches, hewn to shape and fixed by treenails. Paired frames alternate with single floor timbers. All joints were fastened with treenails, there are no iron nails.

Tow was used for caulking the hull. This coarse-fibred scrap from the linen production was mixed with tar or pitch. It was pressed into the seams, which were then covered by laths under the bow and stern. The laths were fixed by small iron nails to prevent the caulking from washing out. As far as I know, the use of tow in medieval shipbuilding is unique, as the hulls on central European inland waters were normally caulked with moss. Because the cultivation of hemp and flax flourished in the region around Lake Constance in the 14th and 15th centuries, the use of these fibres for ship caulking can be easily understood (von Stromer, 1986, 51–57). Hemp and flax were also raw materials for manufacturing ropes and sails, thus the vessel's indispensable textile fittings were produced in the immediate surroundings of Lake Constance. The rigging was quite simple – compared to seagoing vessels – and pictorial sources suggest that all the medieval vessels were equipped with a square sail, like the sailing vessels in the 19th century. The mast height of the *Immenstaad* vessel is estimated to have been *ca.* 10 m.

Fragments of chine-strakes, dated by means of dendrochronology to the 12th century, were detected in the wooden linings of later medieval pits in the towns on Lake Constance and suggest the recycling of disposed scrap materials from dismantled vessels (Hakelberg, Tegel, 1996). If these archaeological finds are not entirely accidental, the monoxyle chine-strake could be considered a common structural component of medieval shipbuilding on Lake Constance. The prevailing evolutionary paradigm, that chine-strakes derive from a split-dugout concept, entails a chrono-technological premise which suggests that even medieval vessels built with chine-strakes are a somewhat archaic remnant of prehistoric or even "Celtic" shipbuilding. I believe, that things are not that simple. Instead of interpreting chine strakes from an evolutionary point of view a more technological and ergological track could be followed.

The chine, the sharp bend from the flat bottom to the more or less vertical side, is a constructional feature closely associated with the bottom-based construction. Chine-strakes strengthen the hull lengthwise and substitute, functionally speaking, for the keel. But whereas a keel represents a symmetrical axis for hull lines and frames, a flat bottom provides a plane. The outline of the plane forms the ground plan of the vessel. If the flat bottom is edged by chine strakes, *i.e.* the vessel has a monoxyle chine, the three-dimensional shape of these specialized wooden components determines the kind of side planking and the design of the flat-bottomed hull, too. Because of the hard chine, flat-bottomed hulls possess good hydrostatical stability and fit the environmental demands of the pre-Alpine lakes perfectly. Because of their shallow draught, they were advantageous in the broad shallow water zones near the shore line of Lake Constance, where the vessels could be punted alongside during calms. Flat-bottomed vessels could also easily approach rural landing places that did not have any jetties. The hull shape made these ships a very suitable means of transport for the exchange between the countryside and the towns, which had harbours with more elaborate waterfront constructions.

Box-like and flat-bottomed hulls with sloping bows and sterns appear in pictorial sources of the 15th to 18th centuries. The earliest comes from an illuminated manuscript from the St. Gallen monastery near Lake Constance and dates from 1452 (Fig. 30.3). It shows a vessel with a box-like hull and sloping bow and stern, rowed by two men. The side planking seems to have been assembled of many planks. The sheer view corresponds perfectly to that of the 14th-century *Immenstaad* vessel. The long

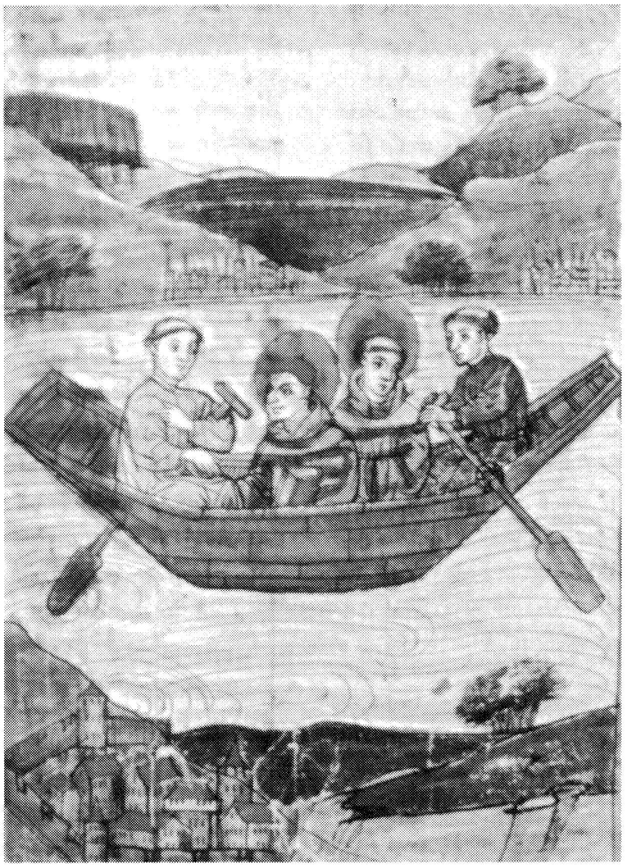
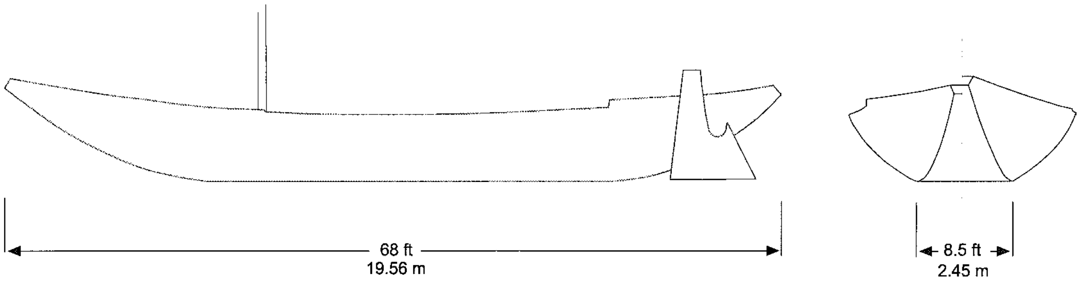


Fig. 30.3. St Gall and St Columban crossing Lake Constance in a flat-bottomed vessel. St Gallen, 1451–52 (courtesy of Stiftsbibliothek St Gallen, cod. 602, p. 33).

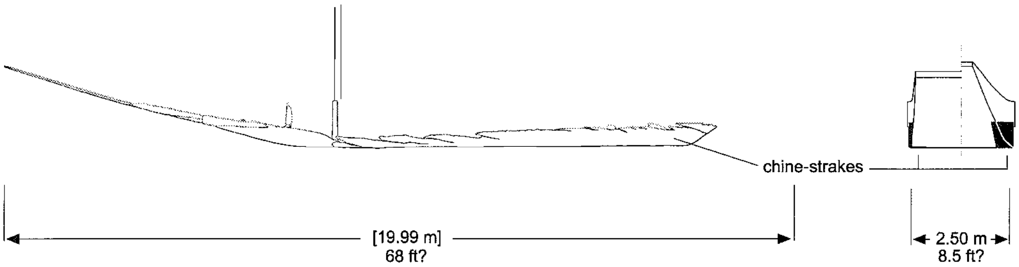
rudder mounted in an oarlock near the bow was used for propulsion, the other aft for steering.

Flat-bottomed hull construction must have undergone a fundamental change in the 17th century. A shipwreck found near Unteruhldingen has been roughly surveyed, but still awaits further examination. The wreck is of a sailing vessel, *ca.* 30 m long, which was built using the bottom-based construction, but with carwel side-planking angling outward, the planks being pinned together by vertically driven iron nails some 40 cm in length. The hull, made of oak planks, no longer has a monoxyle chine-strake, but rather a composite chine made up of single planks. The frames are again curved branches hewn in shape and fixed by heavy iron bolts. Almost the same construction technique was employed for the last wooden sailing vessels of the early 20th century (Fig. 30.4, above; Bloesch, 1988). The sheer and body plans of a post-medieval *Segner* and the 14th-century Immenstaad vessel show clearly two different hull designs (Fig. 30.4):

- In the 12th to 15th centuries flat-bottomed hulls were built in the bottom-based construction and show a box-like body section with almost vertical sides. The bottom was edged by monoxyle chine-strakes carved from logs. The vertical side-planking was clinker built. Frames were made of logs with branches or roots angling away. Joints were fastened throughout by treenails, wedged from in- and outboard (Fig. 30.4, below).
- In the 17th century, shipwrights on Lake Constance developed another flat-bottomed bulbous hull design,



Segner, Lindau 18th-19th c. (1 Lindauer *Werkschuh* [Lindau foot] = 28.8 cm)



Immenstaad-Kippenhorn, 14th c. (1 ft = 29.4 cm?)

Fig. 30.4. Sheer views of a post-medieval Segner *and the medieval* Immenstaad *vessel.*

which was associated with a fundamental change of the bottom-based construction. The body section shows a considerable curvature of the sides. Side planking was now carvel built and angled outward, the strakes were flush and pinned together by long iron nails driven through the plank into the one beneath. Frames were still made of logs with branches or roots angling away, but were fixed by heavy iron bolts and nails. This hull design seems to have been retained almost unchanged until *ca.* 1900 (Fig. 30.4, above).

According to 18th-century records from the town of Lindau, the fundamental measurements of the *Segner* – which had to carry a minimum load of over 44 tons – were a length of 68 feet and an maximum internal bottom width of 8.5 feet (Hartmann, 1808: 82; Leidenfrost 1975: 69). With the Lindau foot (1 *Werkschuh*) of 28.8 cm as the unit, the total length of the *Segner* would be 19.56 m.

The maximum internal bottom width of the 14th-century Immenstaad vessel was 2.50 m. According to the internal bottom width of 8.5 feet in the 18th and 19th centuries, a unit of 29.4 cm can be calculated, which could correspond to a medieval unit of 1 foot. With one foot of 29.4 cm and the traditional *Segner*-length of 68 feet, the original overall length of the 18 m-long *Immenstaad* shipwreck could be calculated to have been about 20 m (Fig. 30.4, below).

The flat bottoms of both hulls, although separated in time by 500 years, not only had the same length, but also almost the same concurrent ratio of length/internal bottom width of 1:8. But the completely different hull design and wood technology resulted in very different capacities. The Lindau *Segner* could carry more than 44 tons, twice the cargo of the Immenstaad vessel, for which a maximum load of between 17 and 21 tons could be determined, depending on freeboard. It is possible that in the course of hull development a fundamental ratio of 1:8 was retained. However, hull design and construction had undergone a thorough change, as I have mentioned above. It therefore might be justifiable to interpret the *Immenstaad* wreck as the remains of a distinctive vessel type preceding the post-medieval *Segner*. On the other hand, pictorial sources suggest that vessels of the box-like "medieval" hull design were still built on Lake Constance in the 18th century, even until the 20th century elsewhere and sometimes employing chine-strakes (Beaudouin, 1985: 60–63, 119–126).

The steering device promises to be another indicator for technological change in wooden shipbuilding on Lake Constance. Whereas in 15th- and 16th-century pictorial sources, two long rudders mounted in oarlocks to the fore and aft sides of the hull are clearly shown (Fig. 30.3), in the 16th century a remarkable side rudder came into use, which ultimately seems to have predominated on the lake in the 17th century, at least for the larger sailing vessels. This elegantly curved rudder-blade, called the "*Schiffsthür*" (ship's door), pivoted on an iron pintle put through two gudgeons on the rudder blade itself and two others in the rudder beam, which crossed the hull aft (Fig. 30.1). So, apart from the change in hull construction and design, we also have a subsequent change of the steering device. Why were the long rudders abandoned in favour of a side rudder? The aforementioned changes in hull design and the increase in hull capacity undoubtely created the need for a steering device that enhanced the directional stability of the square-rigged flat-bottomed vessels. There is no reason to assume that the invention of the side rudder appeared from nowhere, but as far as I know, there is no comparable side rudder known on European inland waters. It could be possible, that a Dutch stern rudder design was adapted on Lake Constance and modified as a side rudder. Due to the gradually sloping flat-bottomed stern of the traditional hull on Lake Constance and the consequent lack of any vertical sternpost or transom stern, the bottom-built concept could have forced the shipwrights to seek alternative solutions for mounting the rudder. The characteristic design and construction of the side rudder remained virtually unchanged until the early 20th century (Fig. 30.1). Foreign influence does not seem to have generally affected shipbuilding on Lake Constance. 15th and 16th-century experiments with a galley *"wie man sie auf dem Meere hat"* (like one has on the ocean), for example, were exceptional and did not prove very successful (Hartmann, 1808: 83).

Whereas the technical development of the Roman and early medieval vessels on Lake Constance is still obscure, recent archaeological finds have been able to provide insight into medieval and post-medieval wooden shipbuilding. The archaeological and iconographical source situation allows us to trace long-term constructional changes between the 14th and the 17th centuries: from flat-bottomed hulls with vertical clinker side-planking and wooden fastenings throughout to flat-bottomed hulls with carvel-built, curved sides employing iron fastenings. Prospering medieval iron technology and the resultant availability of ironwork do not seem to have played a role in medieval shipbuilding on Lake Constance until the 16th century. The post-medieval abandonment of monoxyle chine-strakes and wooden treenails in favor of iron bolts and nails has to be seen in the context of advancing hull design. Additionally, in the 16th century the unique side-rudder appeared. Both medieval and post-medieval hulls still had the flat bottom and the sloping extremities in common. The fundamental changes in flat-bottomed hull design and construction suggest an adaptation to new economic demands and the invention of new shipbuilding technologies. A prospering local economy and the developing global trade in the late Middle Ages possibly triggered them. The bottom-based construction seems to have been employed virtually unchanged until the decline of wooden shipbuilding on Lake Constance. The *Segner* was to survive until *ca.* 1910 when it was finally superseded by the railway lines encircling the lake.

Acknowledgements

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31. The Sailing Qualities of Venetian Great Galleys in the 15th Century Evidence of their Influence on the Development of Sailing Ships in the Atlantic Area during the Following Century

Sergio Bellabarba

This talk is about merchant galleys, also known as great galleys or galleasses. We have devoted considerable time and energy to researching this type of ship and its typical features in the 15th century, which involved building a couple of models. We shall try to describe their characteristics and the influence which we believe they had on the decline of the "carrack" and the adoption of the galleon type in the Atlantic.

So, what were these "great galleys"? A Venetian great galley in the 15th century measured, according to my reconstruction, 45 m from stern to stem-post, and the length to beam ratio was 6:1.[1] Its tonnage was 150 modern-day tons and its cargo capacity was about 250 metric tons. Florentine great galleys did not have to respect the limits so stubbornly imposed by the Venetian Senate.[2] They were longer and in particular, broader in beam. A length to beam ratio of 1:5.3 is documented for the early fourteen hundreds (Lane, 1983:149). They probably sailed better than their Venetian rivals. Fig. 31.1 shows a model of a Venetian galley with all three sails set, something which was probably rare in practice. There are oars on board, but they are not in the rowlocks ready for use because I should like to emphasise that these ships were used principally, if not almost exclusively, as sailing ships. Indeed, they were excellent sailing ships, greatly superior to the round ships of the period. Valuable evidence of this has come from the diaries and journals of pilgrims travelling from Venice to Palestine. Those who could pay for a faster and less uncomfortable voyage travelled on galleys which were normal trade galleys of the "Romania" measure, slightly

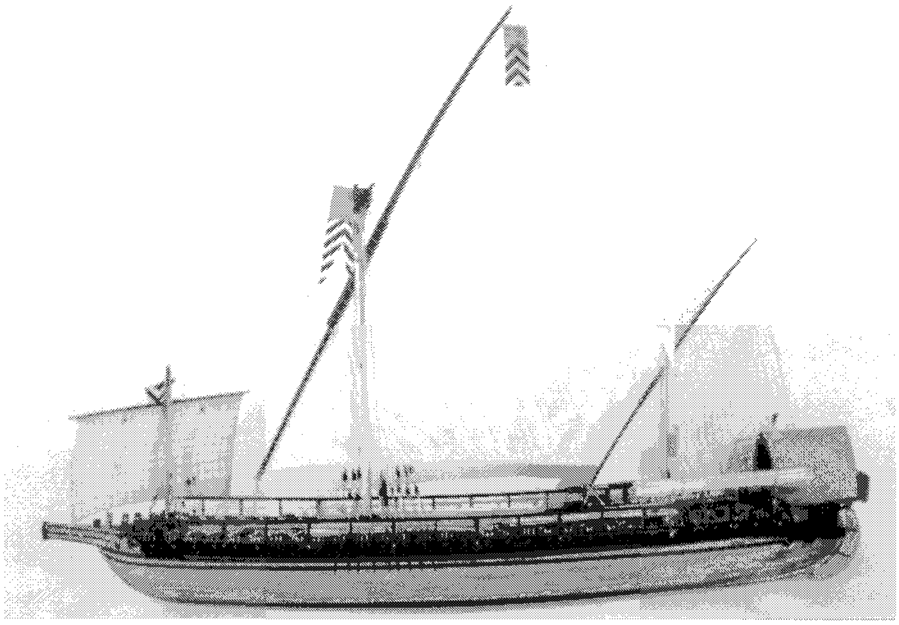

Fig. 31.1 Author's model of a Venetian Great Galley of 1480.

smaller than the Flanders type. The annals of these pilgrimages list the most distinguished names of the European nobility, particularly German noblemen: the Dukes of Austria, Saxony, Mecklemburg, Pomerania...[3]

This fashionable practice of writing or dictating diaries or reports yielded some 27 accounts of voyages in Italian, Latin, French, German and English for the 15th century to which I restricted myself.[4] Of these accounts, some give in great detail the route, form of propulsion (oars or sail) the times of departure and arrival from certain ports of call, the periods when they lay at anchor, the direction of the wind with respect to the route, etc. The data which I managed to deduce from these journals is summarized in Tables 31.1–2.

According to modern maps, a total of the various stretches of voyage which the galleys covered from Venice to Jaffa, amounts to three thousand km or 1600 nautical miles. The average time spent sailing was, according to Table 31.2, 572 hours, so the average speed was 2.8 mph. Later we shall see how to evaluate this fact. The average time under oars was less than 2.5% of the total, and the time under oars plus sail little more than 9%. If we exclude Sanseverino's galley, whose patron, Antonio Loredan, evidently liked to keep his men rowing, there was almost no time spent rowing during the rest of the voyages.

Some of you may perhaps remember an article by Elena Fasano Guarini in the Annales: "Comment naviguent les galères", which quoted accounts of voyages of three Venetian war galleys, two light and a "bastarda", in the Levant at the start of the 16th century (Fasano, Guarini, 1961: 279–296). Sailing under oars took up more than 27% of the time, and mixed (sail and oar) came to 44%. So, there was a substantial difference in the way military and merchant galleys travelled.

Pilgrim journals record the highest speeds which could be reached and 5–6 knots might be considered normal with a good wind. But Seebald Rieter and Pietro Casola did long stretches with Agostino Contarini at an average of seven knots, assuming that he was sailing in a straight line.[5] The same Casola mentioned enthusiastically the speed reached on the Curzola to Lesina section, flying along at nearly nine knots, and perhaps even faster from Zara to Carnaro. The sailors told Casola, that the galley under full sail could do twelve knots with that wind.[6] The Flanders Galleys sped along in the Atlantic too. Travelling to England, Giovenco della Stufa's Florentine galley covered the Bayona (Galicia) to Dartmouth leg in three days at an average speed of more than 8 knots in December 1443 (Mallet, 1967: 89). Luca di Maso degli Albrizzi did Southampton to Finistere at an average of at least 8.5 knots in February 1429 (Mallett, 1967: 261). Here, as before, I am assuming that they sailed in a straight line, which certainly was not the case. So the real speed must have been higher.

Now, just to tease, a comparison between a great galley and a clipper. In the 19th century, clipper logbooks recorded amazing speeds. The Lightning claimed to have reached averages of 18 knots in 24 hours and the Cham-

Year	Diarist	Master (patrono)	Time spent on voyage (1)	Hours in movement (2)
1458	Sanseverino	Antonio Loredan	798	663
1461	Rochechouart	Andrea Contarini	724	572
1479	Peter Rieter	Agostino Contarini	964	578
1480	Santo Brasca	Agostino Contarini	1.064	576
1482	W.v. Guglingen	Agostino Contarini	800	568
1483	Felix Fabri	Pietro Lando	704	468
1494	Pietro Casola	Agostino Contarini	1.005	584
Total			*6.059*	*4.009*

(1) including stops in port during the voyage
(2) excluding time at sea spent lying at anchor

Table 31.1 Overall travelling times and number of hours in movement from Venice – Jaffa (approx. 1600 miles).

Diarist	At anchor	Head winds /becalmed	Using oars	Mixed oars and sail	Storm	Favourable winds	Tacking	Total
W.v.Guglingen	=	72	24	48	144	280	=	568
Peter Rieter	12	120	=	=	12	446	=	590
Sanseverino	5	84	66	117	56	221	119	668
Pietro Casola	68	142	=	88	60	294	=	652
Felix Fabri	74	118	12	=	=	294	44	542
Rochechouart	=	72	=	=	36	464	=	572
Santo Brasca	40	=	=	32	8	415	121	616
TOTAL	***199***	***608***	***102***	***285***	***316***	***2.414***	***284***	***4.208***

Hours spent at sea 4208 – hours lying at anchor (outside port) 199 = actual travelling hours 4009, an average of 572 hours per voyage.

Table 31.2 Details of time in movement

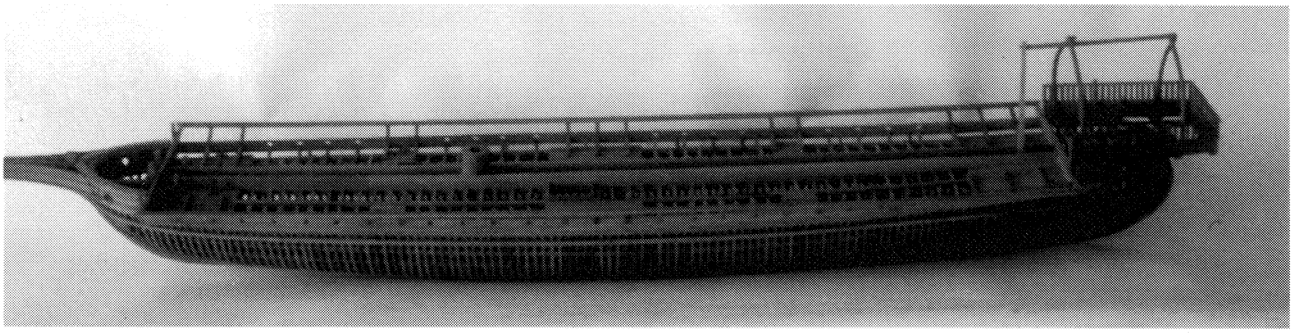

Fig. 31.2 The model of the structure, left unplanked.

pion of the Seas, 19. It is doubtful whether these speeds were effectively achieved. The expression "Yankee log" was used in the English Merchant Navy to ridicule these alleged speeds, which, it was said, were used to advertise the products of certain American shipyards (Learmont, 1957: 225–231). The matter was the subject of lively and lengthy debate in the "Mariner's Mirror" during the 'fifties, with contributions from captains who had sailed big ocean-going sailing ships and from scholars working from documents. It might be concluded that "perhaps" speeds close to 16–17 knots had been reached at times, but that average daily speeds of more than 16 knots are to be considered sceptically in the light of the testimony of seasoned captains (Villiers, Bowness 1957: 341–342; De Courcy Ireland, 1951: 327, citing Captain Macdonald's article of 1948 which rules out speeds greater than 17 knots). Other writers, with various reservations, have expressed the opinion that the speeds claimed could be accepted. (Anderson, Hurst, Lamont, 1958: 328–331; Daniel, 1958: 64; Lyman, Bousefield, 1958: 141). David McGregor, although sceptical of the 19 knots of the Champion of the Seas, maintains that further research is required to estabilish the authenticity of other cases (McGregor, 1957: 342). Howard I. Chapelle (Chapelle, 1958: 66) concludes a critical examination of Captain Learmont's thesis by accepting his main point that the average speeds above 16 knots are "suspect".

Personally we find Captain Clearmont's opinion most plausible, *i.e.* that probably very few ships ever exceeded the 370 miles covered by the Preussen in the Pacific in 24 hours at an average speed of 15.5 knots. But the Preussen was sailing with the help of the Humboldt current, so the speed on water might have been 13–14 knots.

The top speed which Agostino Contarini's galley reached over a long stretch was nine knots, or perhaps more. This is two thirds the speed that one can realistically suppose the best traditional ships reached, apart from exceptional cases. However, the hull of a great galley was about 44 metres long at the water line, as against 60–70 or more of the clippers which I have mentioned. So the well known coefficient of relative speed must be applied to assess the performance of the two hulls objectively. That of the 15th century galley is 0.82 as against 1 or 1.1 of the clippers, if one accepts that the top speeds recorded by the most famous clippers are not completely reliable, or, that they are exceptional cases.[7]

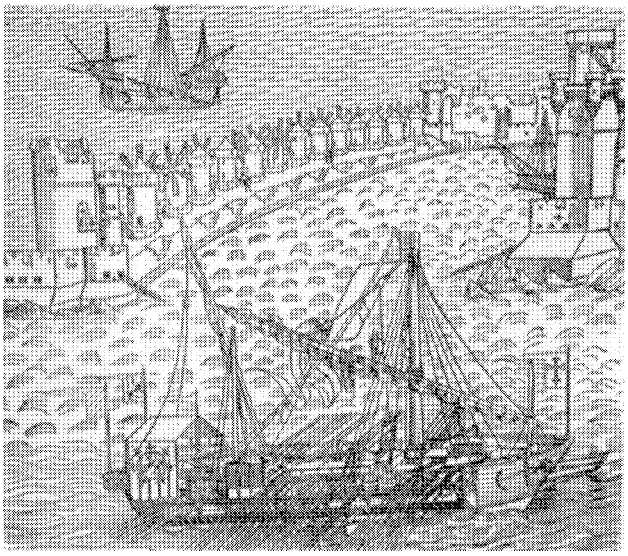

Fig. 31.3 The print by E. Reuwich representing Agostino Contarini's galley of 1483 (the "Contarina") (after: Peregrinatio in Terram Sanctam *by Bernhard von Breydenbach).*

We have seen that the average speed of all recorded voyages to Palestine was 2.8 knots. Well, the average speed of the clippers over long voyages was six knots (Errera, Zanon, 1871: 68; Morcken, 1970: 347). The difference between the average speeds is therefore much greater than that, given above, between the top speeds (and also between the theoretical speeds of the hulls). The reason is, in my opinion, that the galleys did not experience the strong, steady ocean winds.

Another very important aspect in assessing the sailing qualities of a ship is her capacity to sail close to the wind. In a recent study, Burlet (1990: 177) estimated that the light French 17th century galley could sail as far as five points, that is, at roughly 55 degrees. The author also adds that under certain conditions a galley's course could be brought up to 45° from the wind, with the aid of oars. However, Bartolomeo Crescentio was much more optimistic. He considered that a galley could hold a course of 45 degrees without any special devices and still maintain speed (Crescentio, 1601: 125).[8] Leaving out the old carracks and cogs, which could barely sail at less than eighty degrees, the fully developed square rigged ship of the Armada period could sail at an angle of around 65 degrees (Waters, 1949: 96). This is an important difference.

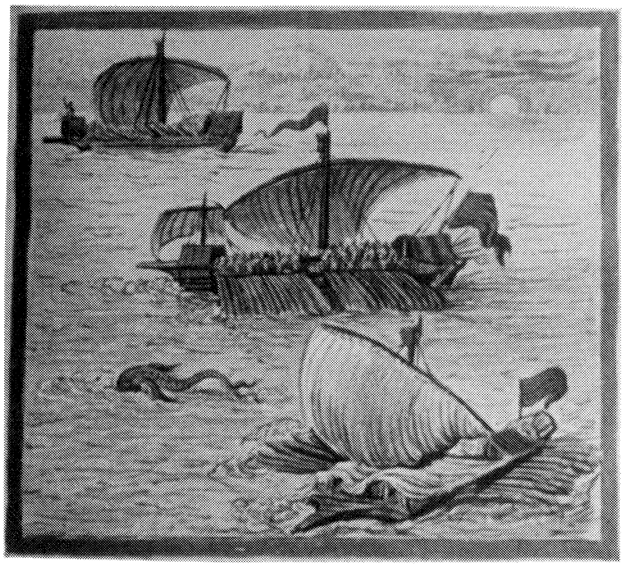

Fig. 31.4 French light and great galleys, circa *1529 (after: the Treaty of the Duke of Clèves).*

Let us look briefly at the safety aspect. It is significant that not one shipwreck was recorded in the whole period (more than two hundred years) when great galleys carried pilgrims to Palestine (a thousand voyages out and back). To be honest, there was almost a shipwreck in 1484, when Pietro Lando's galley ran aground in a storm near Ancona. Lando was a rival of Agostino Contarini, who brought his own galley safely back to Venice...[9]

The picture for trade galleys, which frequently travelled overloaded with goods, is less impressive. In the 15th century there were four shipwrecks on the Flanders route and ten on the Levant routes. But the overall number of voyages was certainly over two thousand in the 15th century alone. The Florentines, on the Flanders route, lost one galley in 250 voyages. There is a splendid description of how these ships coped with heavy seas in Pietro Martire d'Anghiera's report of his voyage to the court of the Sultan of Egypt in 1501.

> "But mainly close to Alexandria a raging tempest struck us. The stretch from Rhodes to Alexandria is four hundred miles, and there, for no less than six days we sailed in a stormy sea... At sunset on December 22nd we reached port, against the expectations of all the Alexandrians, who crowded towers and rooftops to see us dock. Things happened during those days that ancient seamen had rarely seen. The waves were so high that they obscured the sight of , not just the hulls, but almost the masts of the other galleys. The foam whipped up by the billows which struck our galley on the starboard side, fell back into the sea to port as a

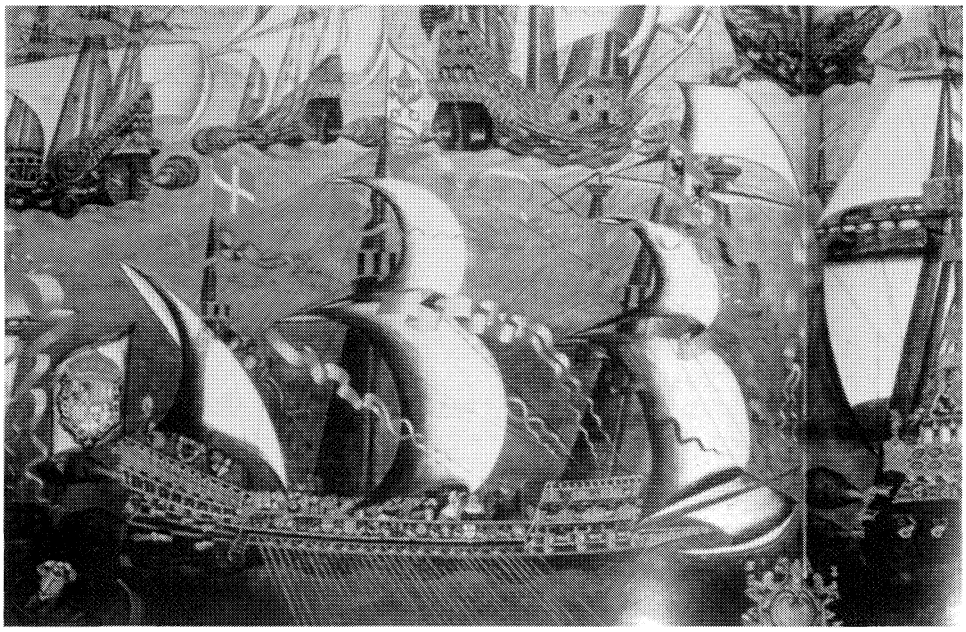

Fig. 31.5 A galleass of the Armada (by an unknown contemporary artist).

> dense cloud...... and I saw with my own eyes that the port side of our galley at times went under water to a depth of two and a half yards........ But these ships are so stout and well-built that even if one of them were totally submerged, it would re-emerge from the rolling waves like an eel or an agile dolphin..." (Pietro Martire, 1533: IX, 80).[10]

Another aspect of safety was the capacity to escape from attacks by men (enemies of the country or pirates) rather than the sea. The cases of great galleys being captured were rather rare. There was a Florentine one in 1473, which was carrying Hans Memlinc's painting of the Last Judgement, which had been bought and paid for by the Medici and ended up in Danzig instead of in the Uffizi.[11] Six Venetian galleys are recorded as having been captured in 1400. However, I should like to mention an example of the opposite, three Venetian great galleys commanded by Bernardo Cicogna gave chase to certain French corsairs and captured several of them (Priuli, for the years 1497–98). [12] There is another curious episode. A pilgrim galley, on board which the Duke of Pomerania was travelling, repelled a savage attack by nine Turkish corsairs in 1497. The pilgrims were obliged to travel unarmed. The Duke, anxious to join the battle, armed himself with a kitchen spit...

A most useful contemporary element for proving that galleys were considered safer than sailing ships, is found in insurance contracts. Systematic research of this aspect in the 15th century still needs to be done, but the facts that I have managed to collect seem significant. A series of facts and figures was collected by Stefani, and among other things, it includes the policies registered in the accounting ledgers of Giacomo Badoer, who was trader and insurer in Constantinople around 1435 (Stefani, 1956, Vol. 1°: 209–228). Processing the data which can be drawn from these sources, it emerges that galleys were charged 4%, at times even 3% in Venice. The rate varied enormously for sailing ships. Contracts ranging from 3% up to 25% have been found. One might think that the difference depended on the route, the age of the ship, the political situation, the season and many other factors. But, discarding the extremes, a considered average lies between 7 and 9%. Another collection of insurance policies has been studied recently, but just the figures published. With regard to the matter in hand, there are sixty policies for transport by ship and by galley, all on the Levant route. The premiums are considerably lower than those taken from the research mentioned earlier, why I do not know. The difference between the premiums for ship and galley transport remains however significant. On average they were 4.6% for ships and 2.2% for galleys (Nehlsen von Stryk, 1988: 500–524). Another set of data, taken from the research of Arcadi Garcia and Nuria Coll indicates that Catalan galleys paid 2 or 2.5 points less than sailing ships (Garcia, Coll 1994: 214–215). There is an interesting coincidence. Frederic Lane quotes a letter written by a Venetian businessman who declared that insuring goods that were to travel on a galley was a waste of money because there was no risk (Lane, 1975: 26, citing Bensa, 1928: 284). The opinion of a Catalan insurer was identical, but from the opposite point of view. He did not insure galleys because there was no risk, and therefore no profit for an insurer (Garcia, Ferrer, 1983: 537). We wonder how many insurers today would take the same line of reasoning.

As a point of reference we examined the strength of the structure of the 15th century galley according to the regulations of the Italian Shipping Register for wooden hulls in the early 20th century (Registro Navale Italiano, 1918; see also Mengoli, 1953: 76–81).[13] The galley conformed to the regulations with regard to the thickness of planking and frames, but the sections of all lengthwise structures, keel, keelson, wales, stringers, etc. were very much below 20th century standards. However, the galley had an extremely stout lengthwise structure which the other sailing ships did not have, the corsia. If this is taken into consideration, the overall total of the sections of the lengthwise elements of the galley was greater than the early 20th sailing century ships.[14]

The second point we wish to cover in this paper is the influence of the great galley or galleass on the development of sailing ships, specifically, square rigged, three-masted ships in the Atlantic area. We are talking about the period when a large ship, with tall or very tall superstructures and a ratio between hull length and width, which was low, three or less, was superseded by a ship with a proportionally longer hull and decidedly less upper work. We know that the terminology for ships of this period (the first half of the16th century) is confusing and unreliable, but for the sake of brevity we are calling the first type a "carrack" and the second, a "galleon".

We wondered how the Venetian or Tuscan great galleys were viewed in the places they visited on the Atlantic seaboard. The captains and crews of the carracks and cogs could see them speeding on their way in all weathers and so also did kings, princes and admirals. A particular episode may serve better than a long discourse to illustrate the general opinion in the North of great galleys. We quote from the most diligently kept journal of Luca di Maso degli Albrizzi on a voyage to Flanders with two Tuscan galleys in December 1429. In the port of Ribadeo the galleys met a fleet of fourteen sailing ships which were due to escort the Infanta Isabel of Portugal as bride to the Duke of Burgundy. Luca di Maso agreed to the King of Portugal's urgent plea to travel with the fleet for their greater protection. They ran into dreadful weather, some ships were wrecked and the fleet dispersed, but the princess finally sheltered in Southampton. The galleys took their leave and set sail for Flanders and the Portuguese ship waited for a favourable wind. When the Duke of Burgundy learned of this, he begged and pleaded with them to return to Southampton to escort the bride as there were no other ships capable of doing so, and even threatened to seize the galleys (Mallet, 1967: 233–254).

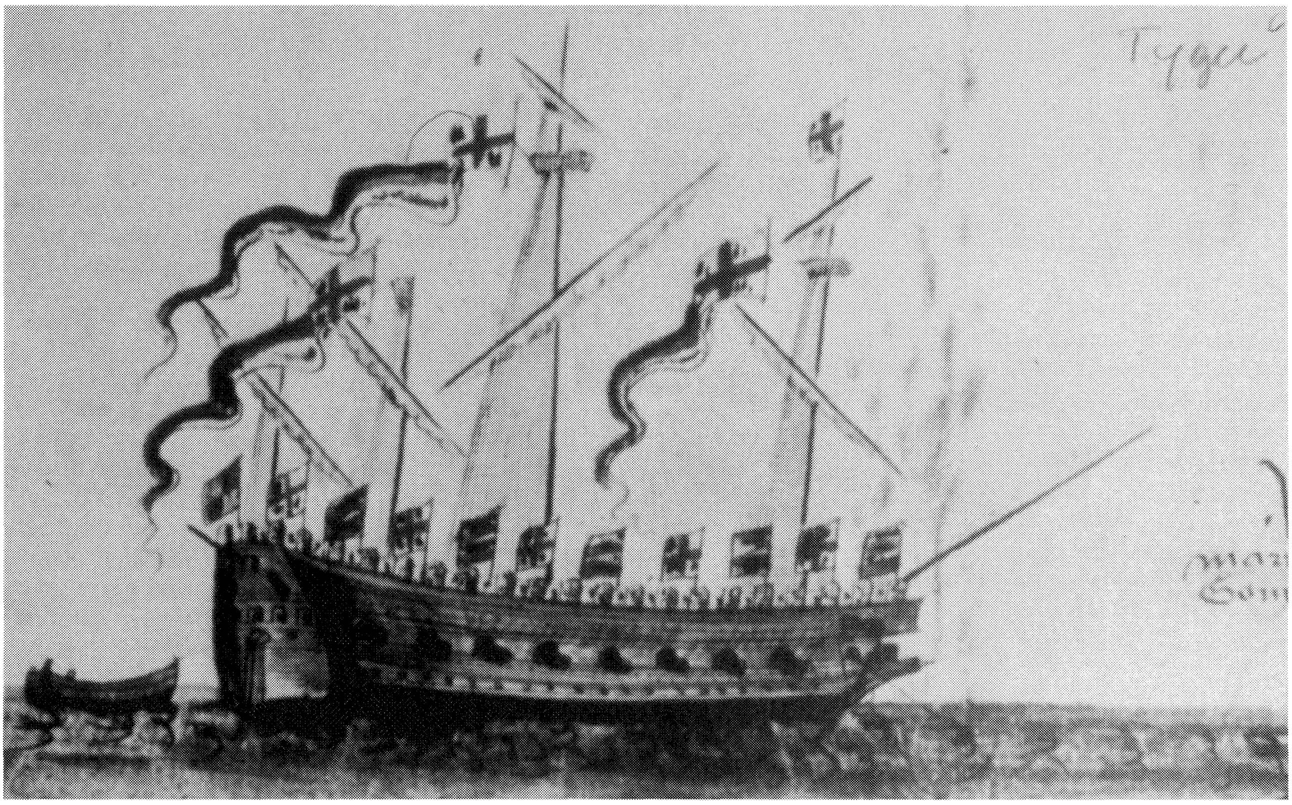

Fig. 31.6 One of Henry VIII's ships, the Tygar (1546) (after Anthony's Roll).

The superiority of galleys over large, carrack type ships must have been fairly obvious. However the prerequisites for using great galleys for trade (the transport of goods with a high unit value per weight or volume) did not exist in the Atlantic. If the galley played a part in displacing the carrack, it can only have done so in the Navy. And indeed there are numerous mentions of such attempts and experiments in the chronicles of the French, English and in particular Spanish, Navies to overcome the shortcomings of the carrack on the basis of the Mediterranean great galley.

Clearly, the steady improvement in masting and rigging from the mid fourteen hundreds to the mid fifteen hundreds gradually diminished the initial superiority of the great galley over the carrack. Yet, at the end of the period we are considering, an indubitably well-informed Englishman, John Montgomery, wrote in 1588, after the Spanish Armada campaign, that the Spanish galleasses (in reality, Neapolitan) were as seaworthy as the sailing ships and they had proved themselves to be a fearsome adversary.[15] He also proposed that the English Navy build at least two of them, a proposal that a committee of admirals accepted, and indeed two were built. Boulind, 1968: 13).

On the French Navy, we know little except the names of three galleasses, or galleons, which Francis I had built for the French Atlantic fleet. (Jal, 1842, 7–23). They were square-rigged. They carried James V's future wife to Scotland in 1538 and the crossing was probably using sails only.[16] In 1527, Clairambault wrote of galleons that "they had no difficulty in gaining the respect of larger ships, nor of galleys". Subsequently, Henry II of France had a score of "roberge" built (De la Roncière, 1923, 457–459). Some contemporaries report that they were the same shape as galleys, indeed, one just needed to increase the freeboard of a galley to get a perfect "roberge". Other say they were galleons, only lower in the water and with more oars. The opinions are contradictory, but the message is clear. They were hybrids based on Mediterranean galleys.[17] But in the years following, in that very period which is most interesting for this research, civil war was raging in France and the French Navy went through a period of disorganisation and decadence.

In the English Navy, experiments begun around 1500. One of the earliest (1515) led to building the "Great Galley" a very big ship (it probably measured about 55 m in length by 10 in beam) which remained in service until at least 1560, undergoing numerous modifications and refittings. It must be remembered that around the mid fifteen hundreds France and England were facing each other in "narrow seas" which were fairly suitable for employing light galleys, but only France had shipyards in the Mediterranean to build and the crews to handle them.

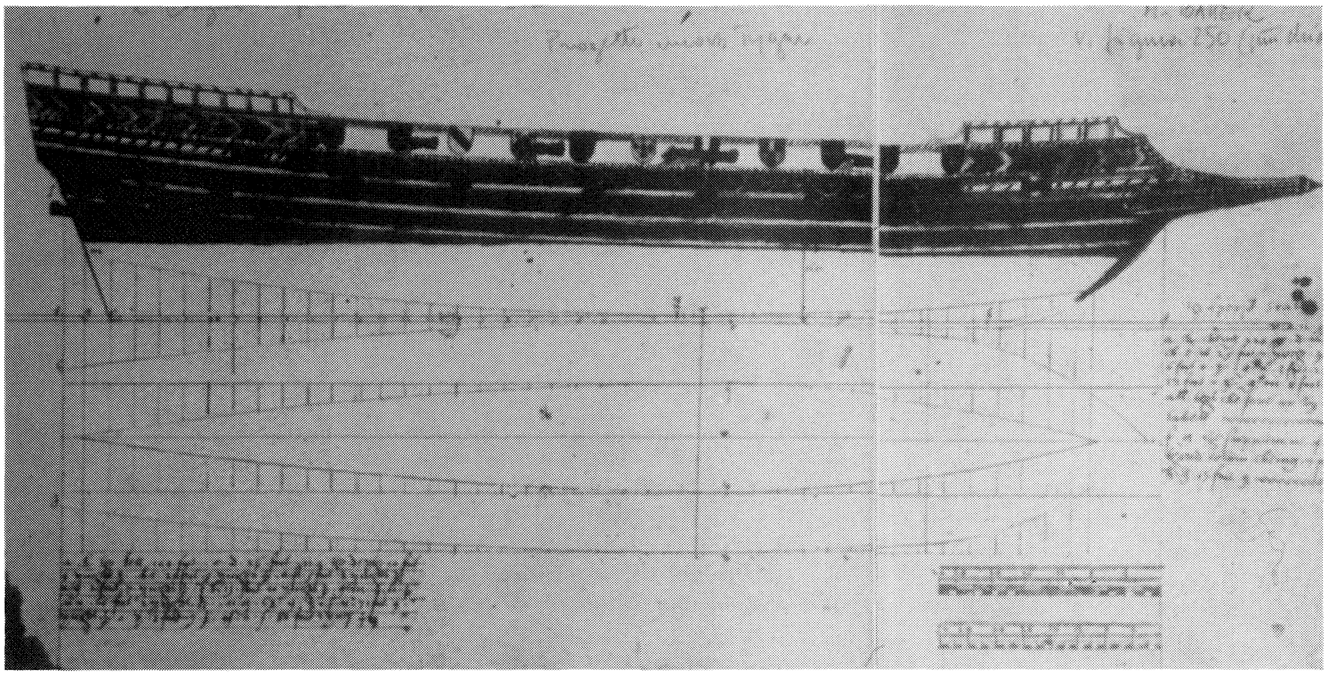

Fig. 31.7 A plan from the Fragments of Ancient English Shipwrightry, *made perhaps in view of rebuilding the Tygar.*

Hence the English tendency to create a suitable means to oppose them (Glasgow, 1969: 465). In Henry VIII's fleet as illustrated in Anthony's Roll, there were a great number of highly unorthodox craft, some with oars, some without. The term frequently used for larger craft was galleass. What is important here is that galleasses were short-lived as oar propelled ships in the English navy, but continued in use for many years as sailing ships. The fact that the use of oars was rapidly dispensed with has usually been interpreted as indicating the failure of these experiments, whereas their importance lies in their success as sailing ships. And during the reign of Elizabeth, ships were reduced to "galleasses" (see the Victory, the Hope: Oppenheim, 1988: 128). Behind these conversions lay the hand of John Hawkins, Treasurer of the Navy and a highly skilled mariner. Opponents of his policies accused him of reducing the Queen's good ships to galeasses (Waters, 1949: 95). It is interesting that the first ships built according to the new concept date from 1573 (the first was the Dreadnought), *i.e.* some years after the launch of a class of Spanish ships with progressive characteristics (Parker, 1996: 269).

There is detailed documentation for the Spanish Navy (Casado Soto, 1988, 118–153).[18] We know that during the early period, the first half of the 16th century, proposals to build craft smaller than great galleys, known as gallizabras[19] were being considered; but other types, specifically called galleasses or galleons such as those built by Alvaro de Bazan the Elder in 1540 and 1550, were adopted. These craft were reportedly very seaworthy. They had two decks and still kept their oar-propulsion capability. It is important to underline the different purposes for which the Spanish monarchy experimented with this new type, compared with England. For Spain it was a question of repelling pirates (principally French in those early days) at sea, and escorting convoys of merchant ships along the routes between the American colonies and the Iberian peninsula.

Subsequently, the Spanish Navy proceeded with great determination to build ships of the new type. In 1567 Pedro Menendez de Avila had a series of twelve "galeones agalerados" built by order of the King. They were nicknamed the twelve apostles, were completely flat, without any superstructure, although light castles were subsequently added at prow and stern. They were excellent sailing ships but never oar-powered. These galeones agalerados had a cargo capacity of 120 modern tons, much less than a Venetian great galley.[20] The Galleass San Cristobal, built in 1577, was considered one of the best ships in the Spanish Navy. On her sailing qualities, suffice to say that she took part in the ill-fated expedition of 1581, to colonise the Straits of Magellan. The expedition ended in disaster, but the San Cristobal was one of the few ships that returned. Lastly, in 1583 the great shipbuilder Cristobal de Barros was charged with constructing nine galleons which had to be bigger and more powerful than those built by Menendez de Avila. They had two decks, forecastle and quarterdeck. They could no longer be propelled by oars. These new craft can be considered the Spanish Navy prototypes for the excellent shipbuilding of the following century. The assessment of Spanish historians as to this

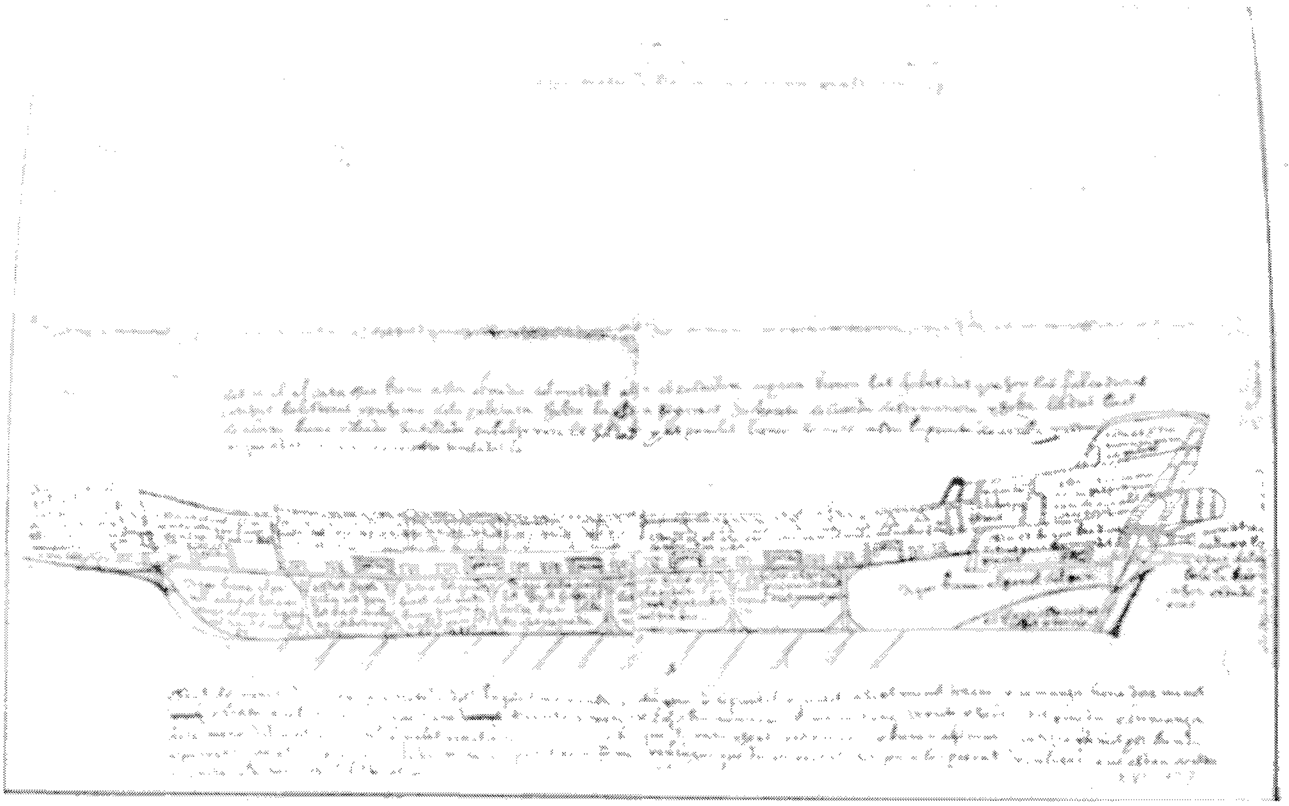

Fig. 31.8 A gallizabra of 1591 (after Casado Soto, 1988).

new class of nine galleons is completely favourable, both with regard to its sailing qualities and as a warship.[21] They were, as stated above, designed for combat and sailing in ocean waters. Personally I should not be at all surprised if it were discovered that the Spanish Navy had had a much greater influence than that which has so far been acknowledged on the other countries on the Atlantic seaboard.

To sum up, we can see three stages of development: the first attempts in the early fifteen hundreds were aimed at creating true hybrids which could be powered by oars like the Venetian, Catalan or French great galleys. Later we find sailing ships still in part similar in appearance to great galleys, and still in part capable of using oars. Finally, in the last decade of the same century, a large, powerful type of ship developed, which resembled the first two only in the form of the prow and the relatively low superstructure. This last type did not use oars any longer. The ratio between beam and length of the last type was established at 1: 3.5–4.0. This is the true forerunner of the 17th and 18th century vessel. The galizabra, reproduced from Casado Soto is an example of a true hybrid, and illustrates the course of the development. An example of the second type is the design contained in the "Fragments of ancient English Shipwrightry" (perhaps a reworking of Tygar's) and it has a width-length hull ratio of 1:5, very close to the 1:5.3 of the Florentine great galleys.

To conclude, if we have correctly interpreted the sequence of the various stages in its development, the Mediterranean great galley played a much greater role in the evolution of the principal vessel of the Atlantic navies than has hitherto been acknowledged.

JOURNALS KEPT BY PILGRIMS TO THE HOLY LAND

Year	Diarist	Ship/master (O=outward)(R=return)
1333	Wilhelm von Boldensele	=
1336	Ludolf von Sudheim	=
1346	Niccolò da Poggibonsi	O & R sailing ship
1384	Simone Sigoli	O & R sailing ship
1384	Lionardo Frescobaldi	O & R sailing ship
1418	Nompar de Caumont	=
1431	Philipp zu Katzenellenbogen	O & R merchant Galley
1434	Mariano da Siena	O & R galley Aloise Vallaresi
1454	Georg von Ehingen	O sailing ship (?) R merchant galley
1458	William Wey	O galley Antonio Loredan; R sailing ship
1458	Roberto Sanseverino	O galley; R sailing ship
1458	Gabriele Capodilista	O galley, R sailing ship
1461	De Rochechouart	O: galley Andrea Contarini
1464	Sebald Rieter senior	O&R galley Agostino Contarini
1464	Gabriel Muffel	=
1474	Alessandro Rinuccini	O&R sailing ship
1475	Alessandro Ariosto	=

1476	Giangiacomo Trivulzio	O galley Andrea Contarini; R: sailing ship
1476	Arcimboldi	O galley Andrea Contarini; R: galley
1480	Francesco Suriano	O merchant galley Francesco Bonhaver;
1482	Walter v.Guglingen	O galley A. Contarini R galley M. Loredan
1483	Felix Fabri (2°)	O galley P. Lando R galley M. Loredan
1483	Bernhard v.Breidenbach	O galley A. Contarini R galley M.Loredan
1484	Francesco Suriano	R galley Agostino Contarini
1486	Georges Lengherand	O galley Pietro Lando
1486	Konrad Grünenberg	O & R galley Pietro Lando
1486	Girolamo Castiglione	O & R sailing ship
1492	Bernardino di Nali	O & R galley
1493	Boguslav v.Lobkovitz	O (& R?) galley Agostino Contarini
1494	Pietro Casola	O & R galley Agostino Contarini
1494	Ludwig v. Greiffenstein	O & R galley Agostino Contarini
1494	Anon. Austrian Pilgrim	=
1496	Arnold v. Harff	sailing ship
1501	Pietro Martire d'Anghiera	Merchant galley

Notes

[1] The principal Venetian sources which contain information as to the dimensions of galleys and of the individual structural elements are listed in the references.

[2] The Venetian Senate considered very important to use the great galleys alongside the light galleys in battle, and this is why their oar capacity was mantained. Moreover, paying wages to the merchant galley oarsmen helped to maintain a reserve of skilled oarsmen for the Republic's military fleet.

[3] A most detailed compilation of pilgrimages made by German people from the 14th to the 16th century, with an impressive bibliography is in Röhricht, 1900. See also Bibliotheka Geographica Palaestinae, 1900, by the same author.

[4] The list of diaries consulted is given in the Appendix.

[5] The accounts which the chroniclers give as to the distances covered and the speed reached were expressed in old miles, the modern metric equivalent of which is not always easy to estabilish. Our calculations were based on the distance effectively travelled (*for example* from Candia to Cyprus) according to modern maps, in relation to the time taken. In order to do this, I had to take into account the old system of measuring time, according to which the day was measured from sunset to sunset.

[6] Seebald Rieter travelled from Ragusa to Corfù (400 km) in thirty hours, *i.e.* at an average speed of 7.2 knots: "und des tags 2 or nach mittag schiften wir von dannen auss der port mit gutem wintt und komen in 30 stunden nemlich uff den 27ten tag juny nach untergang der sonnen gen Corfon in dy port, dahin von Roguss gross meil 300 gerechnet werden..."; from "Seebald Rieters des jüngeren seeligen gethane und aigner handt beschriebene raysen (1479)" in Das Reisebuch der Familie Rieter, Reinhold, Meissner, 1884: 44.

[7] Perhaps it should be borne in mind that at nine knots, Contarini's galley was not running at its maximum, which was around twelve knots (eighteen ancient mph) according to the crew.

[8] Obviously Crescentio referred to the angle formed by the line of the keel and the apparent wind direction. Drift and the difference between the apparent and the real wind direction ought to be taken into account in assessing the effective quality of a galley. Nowadays a yacht with good sailing properties can sail at an angle of 35° with 3° drift.

[9] The journals of the various pilgrims who travelled on board his ships provide a fascinating portrait of this captain over his incredibly long career (about 45 years at sea).

[10] The "Legatio Babylonica" also contains a description of galleys, cargoes, crews and of the (rare) use of the oars. Pietro Martire's galley was sailing in company with four other great galleys.

[11] The person who captured the galley was the famous pirate Paul Beneke.

[12] Cicognas galleys also repelled a sustained attack by twelve French "barze" on the coast of Valencia.

[13] However, we would observe that a galley, in our reconstruction, had a length to beam ratio of 6:1, which lies at the extreme end of the range considered for 20th century merchant ships (from 1:4 to 1: 6), while the length to dept in hold ratio (15:1 in galleys) is well outseide this range which ran from 5:1 to 10:1.

[14] Just an example: the section of the keel plus the keelson of a galley measured 937 sq. cm against 2384 sq. cm of a 20th century merchant ship of the same keel length. But the whole of the structural elements which made up the corsia of a great galley amounted to 4148 sq. cm in section (in our reconstruction).

[15] Montgomery, J., 1570–1588. Montgomery writes " which galliasses... were by forceable storms of roboysterous winds dispersed and driven back again, everyman seeking where he might best find a Port for his safety, in which distress ye said Galliasses passed as well and safely as any others without ye loss of any of them, although some other of their company passed hard enough, after which storm ceased they putt their Fleet in order and again took ye Seas directing their course towards England... (where they) were by His (sic) Majesty's Navy welcomed with ye vallour of worthy men and given Fight, wherein there appeared as I was credibly informed by ye reporte of divers Englishmen serving in our Navy that ye four Galliasses made ye most answerr and offered Fight agains us that was made, whereby they showed themselves to be ships of warlike force, for they haveing the advantage of their oars might leave and take att their Pleasure and by reason thereof did oftentimes issue forth of their squadron....". Montgomery was referring to the battle of 4th August during which the counterattack by the galleasses managed to release two Spanish ships surrounded by the English, and to the sturdy resistance of the San Lorenzo, ran aground during the night battle of the 7–8 August at Gravelines. With regard to their seaworthiness, Montgomery, in the passage, referred to the bad weather the Armada encountered before reaching the Straits of Calais. Montgomery showed himself to be well-informed as to later events, such as the loss of one of the galleasses which sailed West of Ireland (the Girona) but concluded that overall they had demonstrated good sailing qualities.

[16] The Neapolitan galleasses of the Armada were square-rigged, as Montgomery highlights in the "treatise" mentioned. The Scottish galleass of the "Complaint of Scotland" was likewise square-rigged. Examples of square-rigged merchant galleys and galleasses were not rare in the pictorial evidence. See for example Mott, 1988: 51; Fourquin, 1990: 83.

[17] Henry VIII also built a class of 13 "rowbarges" which however, to judge from the crews, were very much smaller than their homonymous French counterparts.

[18] There is an exaustive exposition and a quantity of valuable documents in Casado Soto. Of particular interest is the genesis of the new types, identifiable by means of original unique documentation based on discussions between technicians and sailors.

[19] The zabra was an ancient oar and sail-propelled craft which was widespread in Cantabrico. See Eberenz, 1975: 289.

[20] Casado Soto, page 138 gives the dimensions of the "twelve apostles": a hull length a little over 25 m with a beam to length ratio of 3.5:1. The proportions which are found in the new galleons of 1583 are slightly different, with length from 28 to 31 m and a length to beam ratio of 3.33:1.

[21] The nine galleons in question, without exception returned from the Armada expedition. In all, only one galleon out of eighteen which took the Atlantic route was lost. Instead the Armada lost 70% of the Mediterranean "naves" (probably carrack types) and more than 50% of the German and Flemish "urcas" (holk?): see Casado Soto: 248.

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32. The Venetian Merchant Galley and the System of *Partisoni* – Initial Steps towards Modern Ship Design

Ulrich Alertz

Written sources

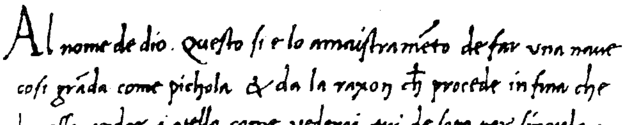
Today you can hardly imagine how a large and complex vessel such as a merchant galley could be built without any form of plans. And yet these ships were seaworthy. Just as the carpenters of the day mastered every stroke by practising it so long that it could be carried out automatically, the budding shipwright learned his teacher's instructions by rote. The master shipwrights – we can assume – recited aloud the essential details of their projects.

Such verses were later collected to form the earliest written building instructions, lyrical in form and based on words and numbers (Fig. 32.1). The *Fabrica di galere*, of about 1410, passes these much older design methods down to us. The early Italian shipbuilding manuscripts give no visual images of ship design; instead they give what amounts to an acoustic idea of the master shipwrights' teachings. Parts of the *Fabrica* are repeated in 1470 in the *Ragioni antique* in Greenwich (Bonfiglio Dosio *et al.*, 1987). (Fig. 32.6).

First examples of sketches of individual boat – or ship-components showing the deliberate use of parallel perspective projections are found in Giorgio Trombetta's notes dating from the 1440s. His sketches are small and drawn freehand (Fig. 32.2). Such plans were further developed in the course of the next hundred years until they had reached the level of large-format line drawings of engineering standards (Fig. 32.3).

Pre Theodoro, a Venetian master shipwright of the mid-16th century, used his drawings expressly as building plans to define the form of the mainframe and the rounded stem and sternpost. The dimensions of a similar merchant galley can be found in the anonymous Misure di vascelli of 1547 (Tucci, 1963–1964). Allessandro Picheroni – a contemporary of Pre Theodoro, but not a shipwright – gives for the first time the deck and outrigger contours of this vessel (Fig. 32.4).

These early naval manuscripts, written for the initiated and the expert, are very difficult to interpret. However, at the climax of centuries of development Steffano de Zuanne, a master shipwright, displayed the achievements and successes of a long epoch of medieval shipwrightry drawing to its close. His *Architettura Navale* of 1686 gives us the key to understand the older texts (Fig. 32.7).



Al nome de dio. Questo si e lo amaistramẽto de far vna naue
cosi grãda come pichola & da la raxon ch̄ procede in fina che
la possa andar a vello come vederai qui de soto per singular.

Fig. 32.1. Florence, BNCF, cod. Magliabecchiano classe XIX, 7, Fabrica di galere, *f.33r.*

The principles of early Venetian naval architecture

These manuscripts provide a unique source of written evidence, which can be used as a framework to identify and classify the scatterd ship finds of the later medieval and early modern period. But they did more than simply describe. Since they were intended for practical usage, they in fact contributed to ship development itself.

The naval architect of the Middle Ages was not able to discover experimentally the most efficient shape for a stable and commodious vessel. It was essential to reduce to a minimum the life-threatening risks of a seriously flawed vessel, but different means had to be found. The shipwright, basing his ideas on successful predecessors, aimed at laying down simple rules which would govern the main dimensions and form of the hull. Great importance was attached to certain crucial components. In addition to keel, stem and sternpost the mainframe proved to be vital. The shape of all the other frames could be found with a series of carefully selected variations – known as *'partisoni'*.

First the shipwright lays down the keel (*'colomba'*), erects stem and sternpost (*'aste'*) and designs the mainframe (*'corba in mezo'*). Calipers are used to determine the frame width at different heights. Then he calculates

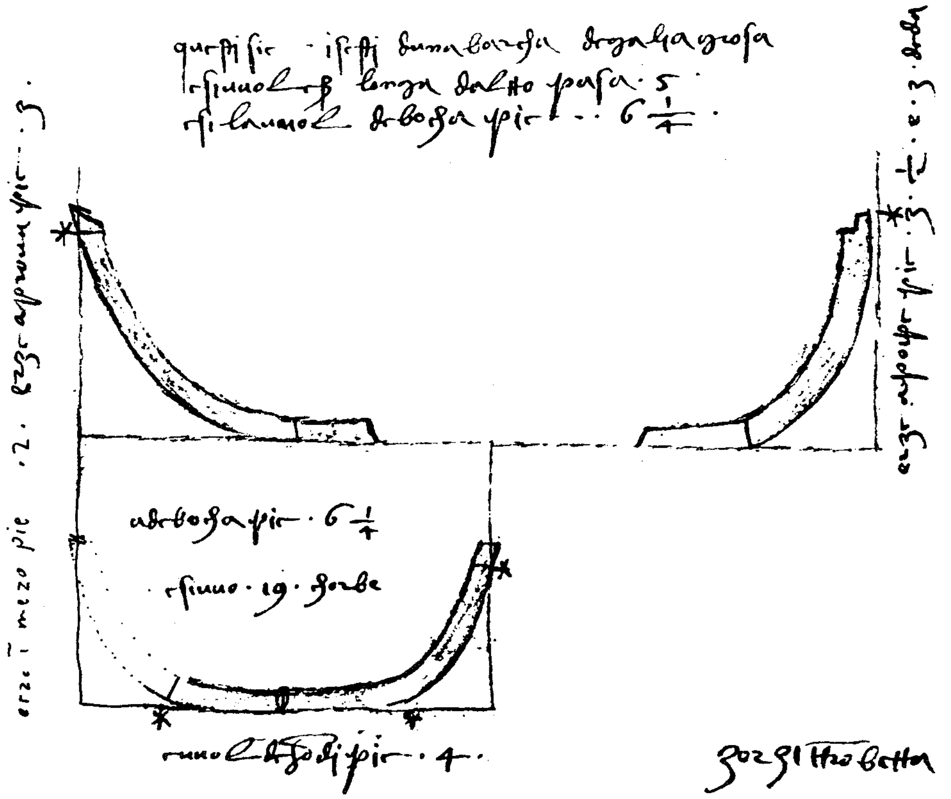

erze i mezo pie
6 1/4
5
19
4
Zorzi Trombetta

Fig. 32.2. Moulds of the 'barcha de galia grosa' *and the signature of* 'Zorzi Trombetta' *(London, BL, Cottonian Ms, Titus A.26, Giorgio Trombetta, f.40v, f.55r).*

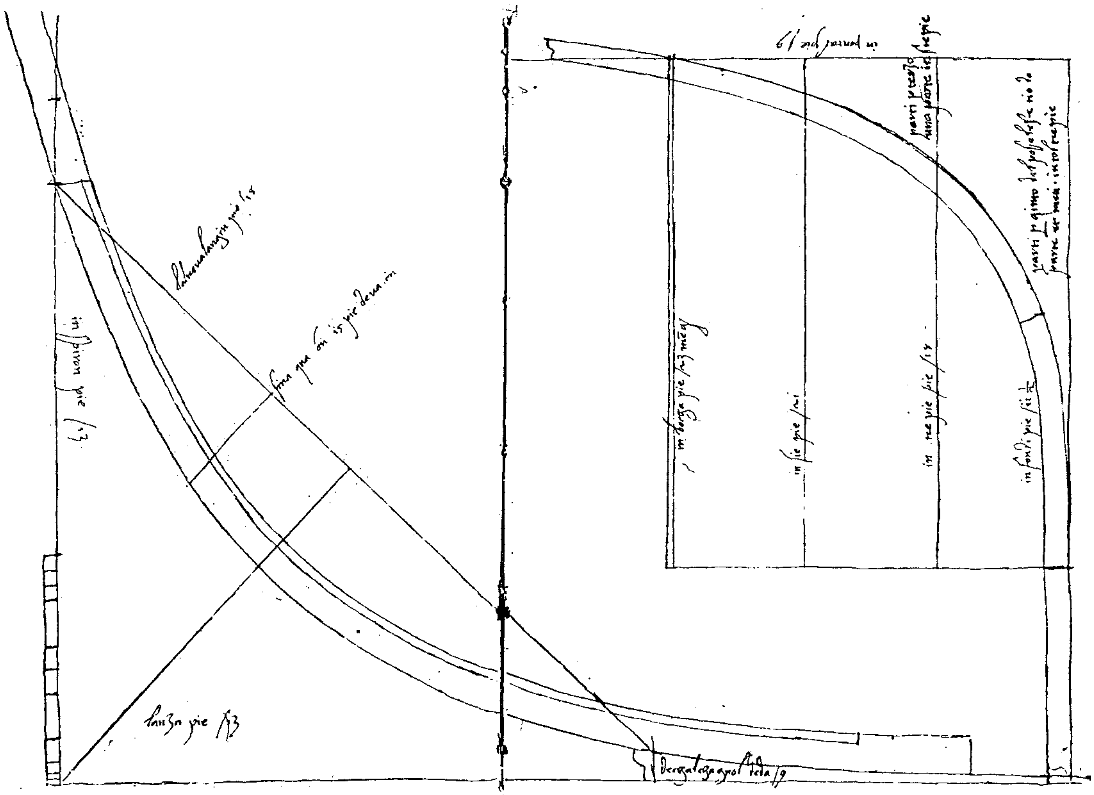


Fig. 32.3. Stem and mainframe of a 'galia grossa' *(Venice, BNM, Ms. italiani, classis IV, 26, Pre Theodoro, f.III).*

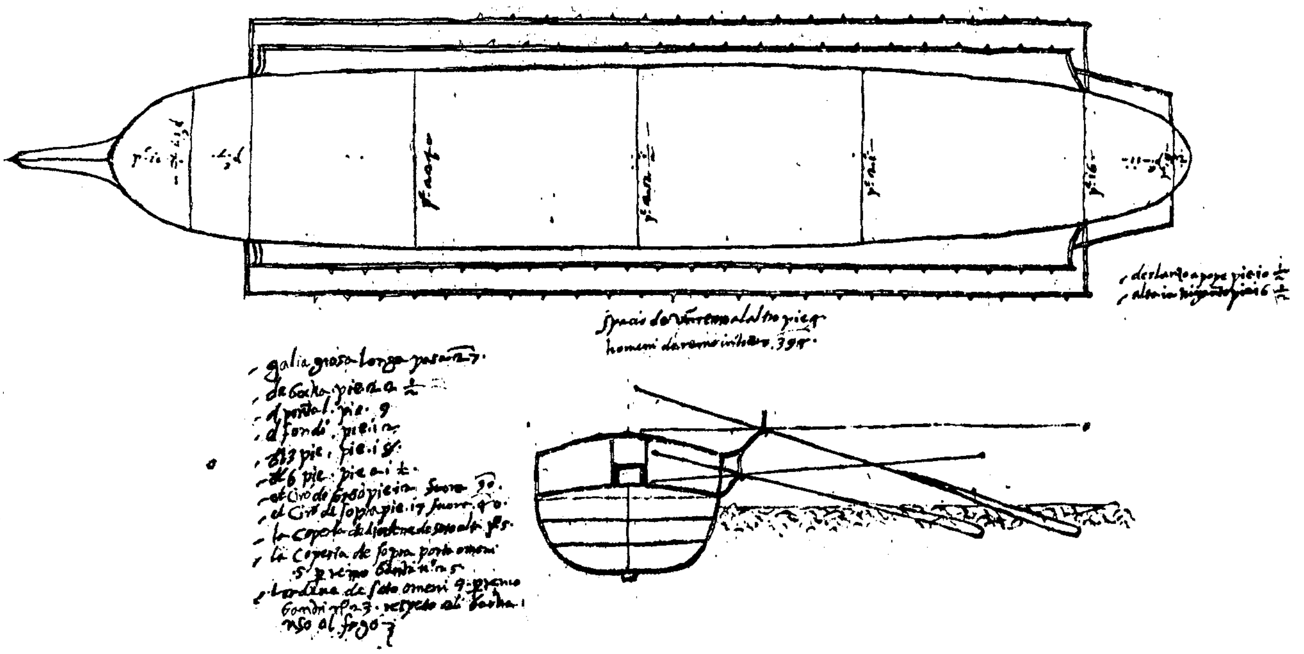


Fig. 32.4. 'Deck lines and mainframe of a 'galia grosa' *(Venice, BNM, Ms. italiani, classis VII, 379, Alessandro Picheroni, f.8).*

the shape of two *'cavi di sesto'*. These are aligning frames which form the forward and after ends of the *'corbe in sesti'*. The mainframe serves as pattern. Finally he designes all frames between the aligning frames accordingly, so that the corresponding calliper marks can be virtually connected by faired lines (Fig. 32.5).

The design of the 'cavo di sesto'

Building regulations explain step by step how to develop the *'cavo di sesto'* from the mainframe's shape. The first step, called *'partison del fondo'*, shortened the flat bottom of the frame (Fig. 32.6). In a second step the *'cavo di sesto'* is set on a plinth (*'stella'*), so that the deck rises slightly towards the ends, and the waterlines run at a more pronounced angle fore and aft at the bottom (Fig. 32.7). The third step, the *'legno in ramo'*, increases the frame side angle. Compared with the U-shaped mainframe the *'cavi de sesto'* are more V-shaped. Steffano de Zuanne gives the procedure's result (Fig. 32.8).

Pre Theodoro and Steffano de Zuanne mention a fourth step, the *'scorer delli forcami'*. This process restores the frame's flowing curvature. It determines by how much the mark where to connect the bottom-mould to the top-mould has to be moved.

The 'partison' diagram

According to Steffano de Zuanne, all the 255 floor and futtock timbers needed to build the 85 'corbe' of a galeass can be prepared with only two moulds.

> Diro solo che con duoi soli sesti partiti come sopra si preparano pezzi n° 255 tra corbe, e forcami che occorono per una Galeazza tutti diversi l'uno dall'altro ... che posti al loco destinato formano un corpo perfetto. (London, BL, Additional Ms 38655, Steffano de Zuanne, f.18v)
>
> *I just say, that with only two moulds, partitioned as above shown, you can prepare the 255 floor and futtock timbers – all different from each other – which are necessary for a galeass ... so that, if they are positioned in their right place, form a perfect hull.*

The numerical values for the separate steps of the 'partison' procedure are stated by the shipwright only for the two *'cavi di sesto'*. The values for all the intermediate frames have to be determined by the carpenter using a geometric process. Steffano de Zuanne divides the short side of a right-angle triangle into exactly the number of unequal parts as he wants to calculate frames between mainframe and aligning frame (Fig. 32.9).

n = number of "onze"

1 / ((n+1) * (n/2)), 2 / ((n+1) * (n/2)), 3 / ((n+1) * (n/2)) and so on up to n / ((n+1) * (n/2)).

These calculated frames are called '*onze*' – that is every fourth frame of the merchant galley. The values for each individual 'onza' can now be found using a compass. *'Partison del fondo'*, *'stella'*, *'ramo'* and '*scorer*' are determined similarly. Presumably the same diagram is used for this, but the values are read off at different positions.

The term '*partison*' is already mentioned by Trombetta[1]

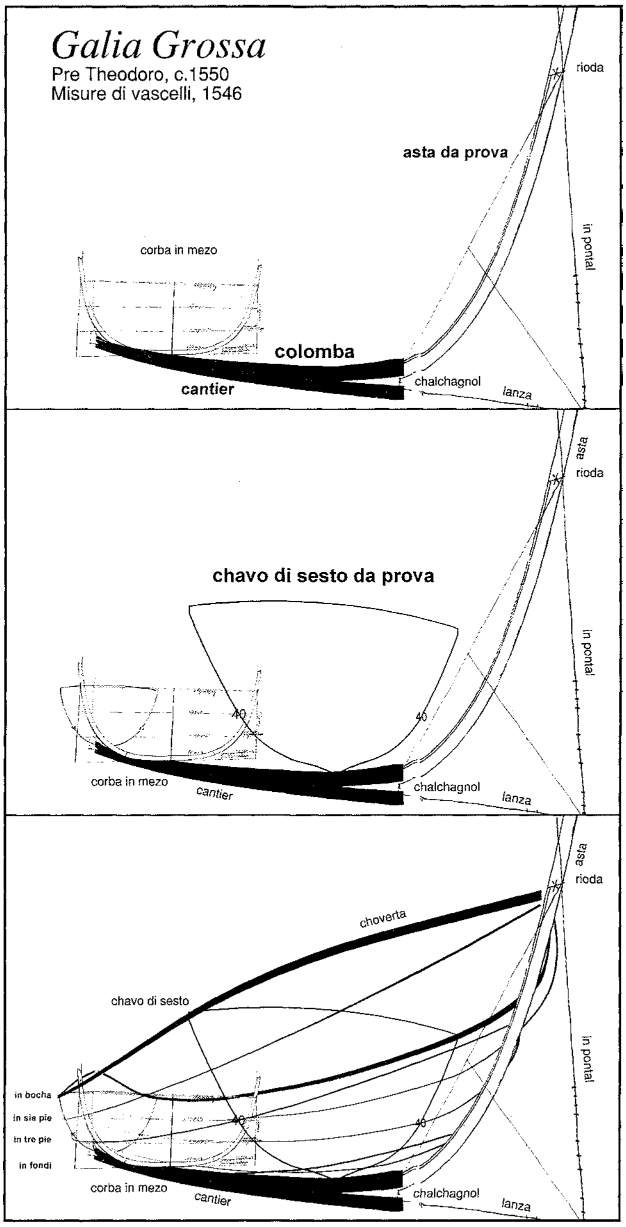

Galia Grossa
Pre Theodoro, c.1550
Misure di vascelli, 1546
rioda
asta da prova
in pontal
corba in mezo
colomba
cantier
chalchagnol
lanza
asta
rioda
chavo di sesto da prova
in pontal
40
40
corba in mezo
cantier
chalchagnol
lanza
asta
rioda
choverta
chavo di sesto
in pontal
in bocha
in sie pie
in tre pie
in fondi
40
40
corba in mezo
cantier
chalchagnol
lanza

Fig. 32.5. The procedure of designing a 'galia grossa'.

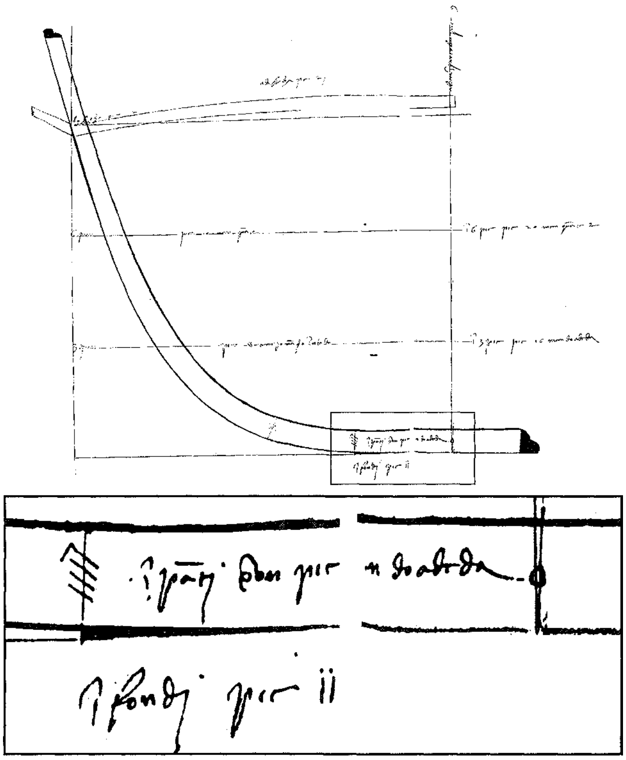


Fig. 32.6. 'Partison del fondo' *(Greenwich, NMM, NVT 19,* Ragioni antique, *f.66v).*

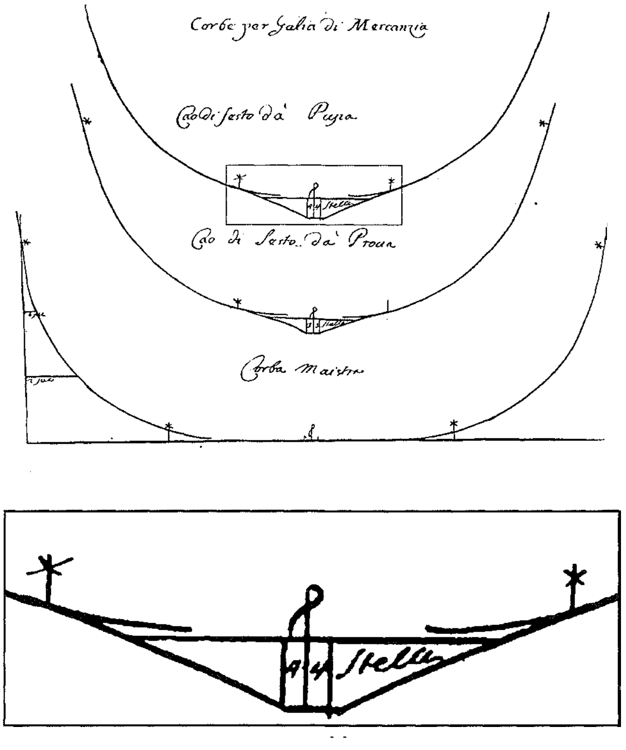

Corbe per Galia di Mercanzia
Chavo di Sesto da Pupa
Chavo di Sesto da Prova
Corba Maistra
Stella

Fig. 32.7. 'Stella' *(London, BL, Additional Ms 38655, Steffano de Zuanne, f.20r).*

and the anonymous author of the *'Fabrica di galere'* knows about the use of similar calculating tabletts for the cutting of sails.[2] Both authors – most probably no shipwrights – are possibly not fully introduced into the professional secrets of whole moulding. The term *'partison'* and the corresponding procedure is perhaps much older. With regard to the activities of greek shipwrights in the late 14th and early 15th century (Bondioli, Penzo, 1999), and knowing that galleys were defined as small dromons about 400 years before (Alertz, 1995a, 142; Alertz, 1995b: 60–66), one might even assume that the term actually is of greek origin. 'Παρατάσσω' meens *'to raise'*, *'to erect'* or *'to put up in a row side by side'*. Originally the whole procedure of erecting frames might have been called

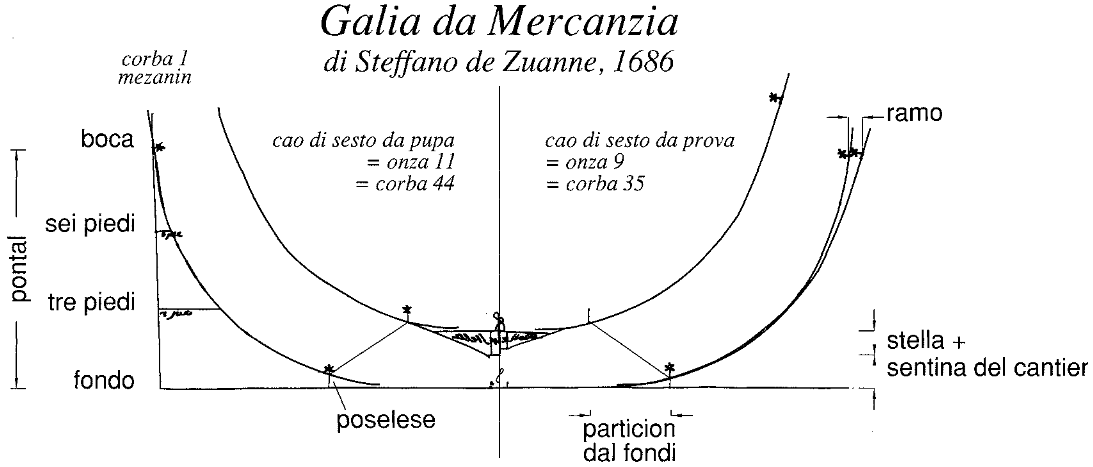

Galia da Mercanzia
di Steffano de Zuanne, 1686
corba 1
mezanin
boca
sei piedi
tre piedi
fondo
pontal
cao di sesto da pupa
= onza 11
= corba 44
cao di sesto da prova
= onza 9
= corba 35
ramo
stella +
sentina del cantier
poselese
particion
dal fondi

Fig. 32.8. The effect of 'partison', 'stella' *and* 'ramo' *according to Steffano de Zuanne.*

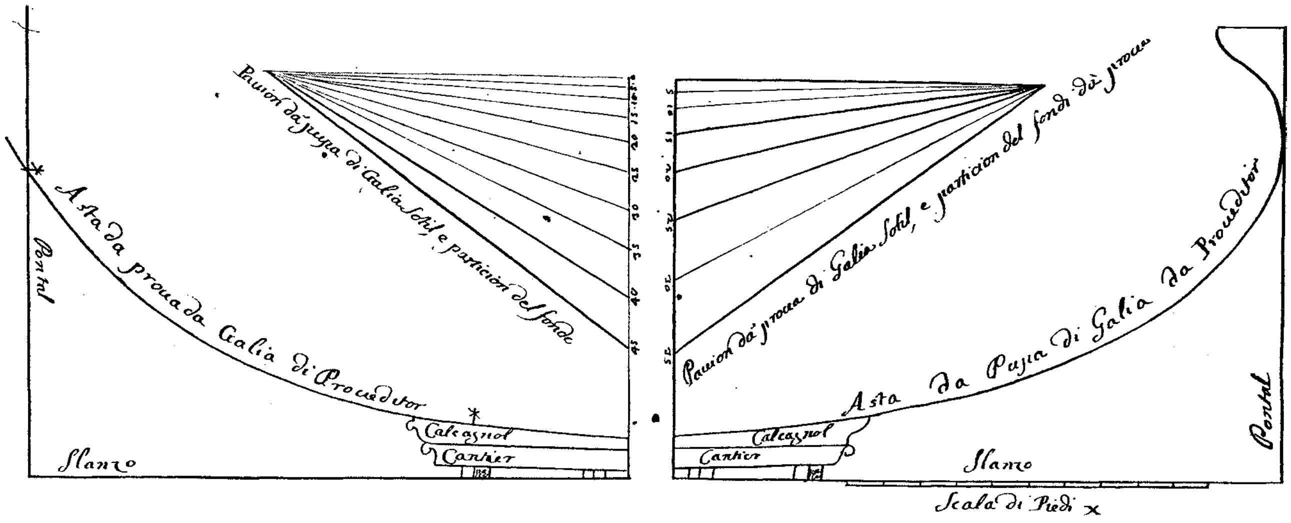

Pontal
Slanzo
Calcagnol
Cantier
Scala di Piedi

Fig. 32.9. London, BL, Additional Ms 38655, Steffano de Zuanne, f.8v-9r.

'Παράταξις'. Byzantine shipwrights might have introduced it into Venetian naval architecture well before 1400. But we do not yet know enough about these early influences. In the 16th century at least the word '*partison*' had already lost much of its comprehensive meaning and was then applied to the '*partizione*', '*partitioning*' of the calculating tablets.

'Maistre'

One severe fault must not be overlooked. The '*partison*' procedure can only be applied at the central part of the hull. The ends are outside its scope. It appears that even the frame-first method does not extend to these two areas. Ribbands, the so called '*maistre*', are curved into stem and sternpost in the ancient way, and frames are added later to reinforce the structure. Presumably '*sesti*' as shown in the '*Fabrica*'[3] would be used to check and adjust the curvature. Two templates are positioned half-way between '*chodera chorba*' – which is called '*cavo di sesto*' in the 16th and 17th century – and hull end at the point marked '*poselexe del choltro*', the joint areas between keel and stem/stern (see Alertz, 1995a, 146).

'Partison' *based computer algorithms*

The Venetian shipwrights had developed a numerical procedure for designing ships. The ship's shape is recorded digitally. Dimensional data using a two-dimensional co-ordinate system on a series of planes define the shape and position of the critical components. This is exactly what is needed to transform the medieval art of ship design into a modern computer algorithm. The following function 'fPartison' calculates the partison value for every '*onza*'. It is written in LISP. Every expression is put in parenthesis. The operator – which may be a function itself – is noted first.

```
(defun fPartison (Frame CaoDS / Factor mx)
 (setq Factor 0)
 (setq mx     0)
 (if (>= (abs Frame) (abs PM))
  (setq mx (+ (– Frame PM) (* (/ (– Frame PM) (– CaoDS
  PM)) PM)))
 )
 (if (> CaoDS 0)
  (progn
   (if (= MezLun T)
;Bartolomeo Crescentio's 'mezza luna'
     (setq Factor (abs (– 1 (cos (* (/ pi 2.0) (/ mx
     CaoDS))))))
;Steffano de Zuanne's triangle
     (setq Factor (/ (* (1+ mx) (/ mx 2.0))
                     (* (1+ CaoDS) (/ CaoDS 2.0))))
    )
  )
 )
 Factor
)
```

LISP expressions:

defun	marks a function
setq	set quoted: 1. Argument is set equal to the 2.
if	conditional expression
progn	keeps several lines together
abs	sets the absolute value
cos	cosinus
pi	3,14...

Variables:

Frame	no. of currently calculated frame
CaoDS	no. of 'cao di sesto'
Factor	return value
PM	number of equal frames in the middle of the hull
MezLun	boolish variable ('meza luna' – or triangle)
mx	saves the position of the currently calculated frame on the partison-scale with respect to the parallel part amidships

Reconstruction

Every ship that was built according to any kind of *'partisoni'* can be virtually reconstructed in this way. It is now possible to produce and compare lines drawings of different versions within a few minutes. The 16th and 17th century sources provide the necessary input data for the partison algorithms, so that the lines of the frames and ribbands can be drawn automatically. The corresponding values of the 15th century vessels must be deduced from the dimensional information given in the older manuscripts. The hull's ends and the outrigger are calculated using functions which imitate the above mentioned 'maistre'. Smooth lines are taken as conditional.

Three different types of merchant galleys can be identified in the above mentioned Venetian naval manuscripts for the period between 1400 and 1700.

The Flanders-Galley of 1410 linked Venice to the harbours of England and the Netherlands and took pilgrims to Palestine (Fig. 32.10); However the demand for such voyages ceased in the 16th century. The number of great galleys in the Arsenal was reduced from about 30 in the days of Breydenbach, Reuwich (Kreuer, 1990), Fabri (Hassler, 1843–1849: 117–127) and Casola (Newett, 1907: 155–160) to only 6 in 1560 (Lane, 1965: 230).

This time of crisis saw the next galley built by Pre Theodoro in about 1550 (Fig. 32.11). The extra upthrust below the bow made it possible to accomodate heavy guns forward. The same type of merchant galley was transformed into a galeass to fight at Lepanto two decades later.

Steffano de Zuanne designed one of the last great galleys exclusively with the help of *'partisoni'* (Fig. 32.12). The oar system has changed to the *'a scaloccio'* system with now four men to each oar. The free deck space behind the rowers serves for the merchants' convenience. Only two of these vessels were travelling in the adriatic sea in the times of Vincenzo Coronelli (Witt, 1970: 13–15).

The significance for the development of sea traffic

The *'partison'* procedure fulfilled the most important prerequisite for the expansion of Mediterranean sea traffic. Without its rules, every galley would have been a unique vessel, like the dromons, the Viking ships and the Hanseatic cogs. It would have been possible to imitate individual successful vessels, but continuous development would not have occurred. The qualities of the ship – hydrostatic and hydrodynamic characteristics – which in earlier times could only be attributed to the skills of the master shipwright, could now be described, compared and to a certain extent explained by rules, dimensional relationships and drawings.

The merchant galleys were designed and commissioned with a level of confidence previously unknown. Not one of the pilgrim galleys, for example, was lost through faulty construction or effect of wind and sea. Contemporaries considered the merchant galleys to be the safest, most reliable, and fastest means of transport.

Venetian documentary sources

Florence, Biblioteca Nazionale Centrale, codice Magliabecchiano classe XIX, 7 (123 fols) *Fabrica di galere = Libro di Marineria* (late 15th – or early 16th -century copy of a Venetian original of *circa*1410, almost identical with the *'Arte de far vasselli'*).

Greenwich, National Maritime Museum, NVT 19 (67 fols) *Ragioni antique spettanti all'arte del mare et fabriche de vasselli* (Venice 1470–1529, with partial copy of the *'Fabrica di galere'*).

London, British Library, Additional Manuscripts 38655 (72 fols) *L'Architettura Navale di Steffano de Zuanne de Michel Vice Proto de Marangoni* (Venice 1686).

London, British Library, Cottonian Manuscripts, Titus A.26 (62

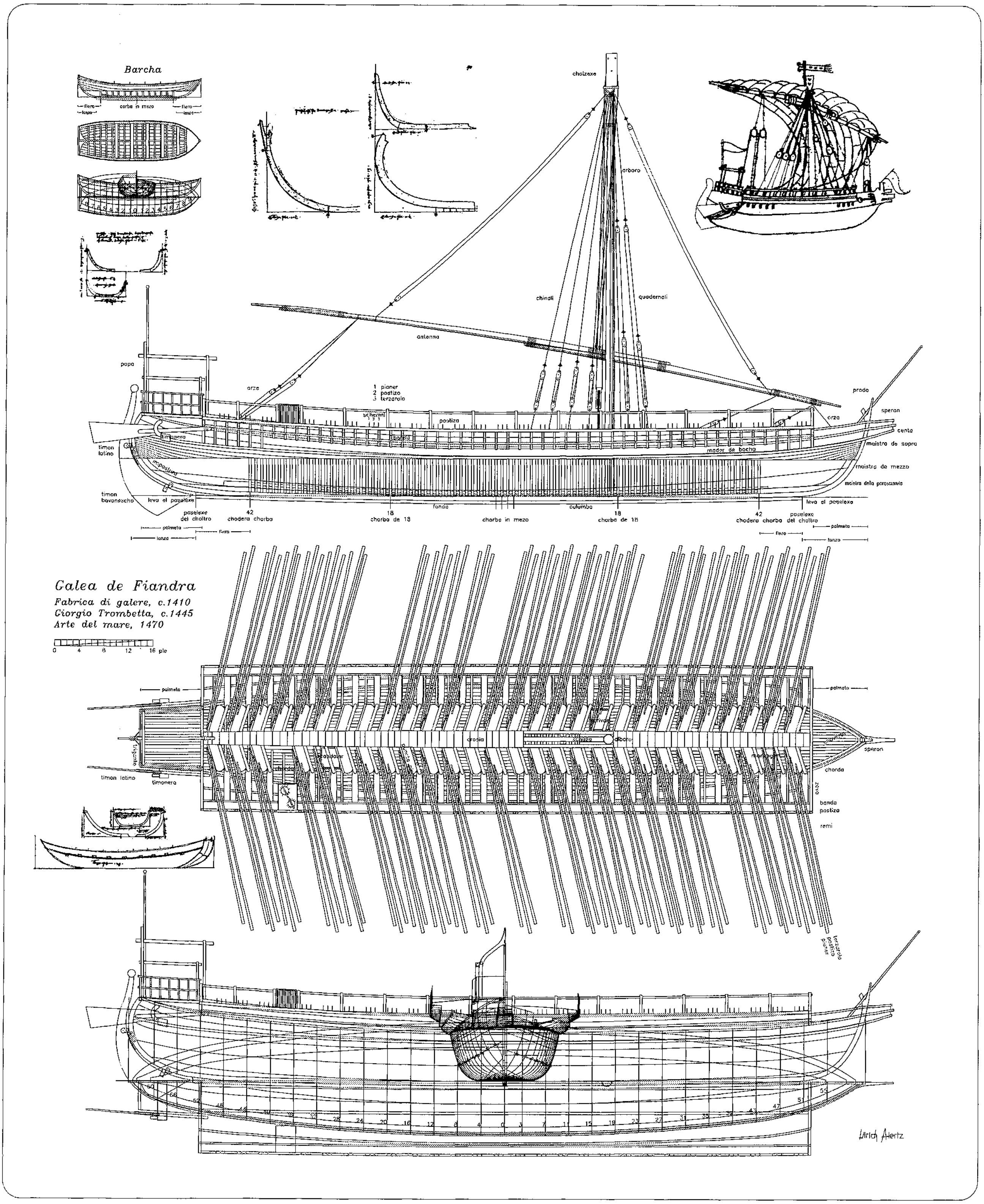

Barcha
fiero
corba in mezo
fiero
lanza
lanza
cholzaxe
arboro
chinali
quadernali
antenna
popa
orze
1 pianer
2 postizo
3 terzarolo
schermi
1 2 3
postiza
prodo
orza
speron
centa
timonera
timon latino
maistra de sopra
mader de bocha
imposture
maistra de mezzo
maistra della porsezzola
timon bavonescho
leva el paselexe
paselexe del choltro
42
chodera charba
fondo
18
charba de 18
charba in mezo
columba
18
charba de 18
42
chodera charba
paselexe del choltro
leva el paselexe
palmeta
fiero
lanza
palmeta
fiero
lanza
Galea de Fiandra
Fabrica di galere, c.1410
Giorgio Trombetta, c.1445
Arte del mare, 1470
0
4
8
12
16 pie
palmeta
palmeta
timon latino
timonera
crosia
schaza
arivar
alboro
speron
chorda
chorda
morangon
zovo
banda postiza
remi
terzarolo
postizo
pianer
Ulrich Alertz

Fig. 32.10. Galea de Fiandra, *1410.*

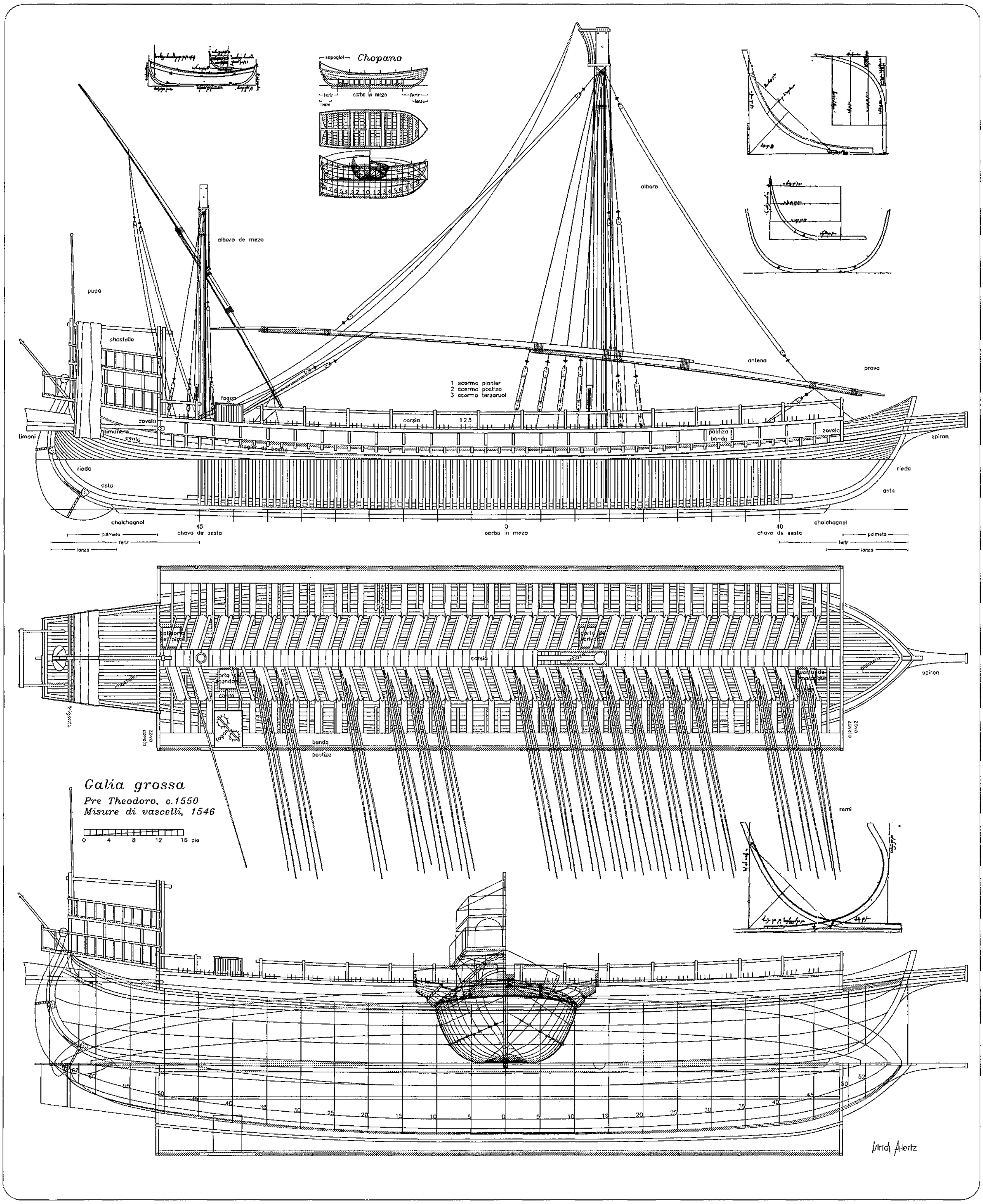

Chopano
zapogiol
ferir
corba in mezo
lanzo
albero de mezo
pupa
chastello
fogon
zovolo
limonera
limoni
rioda
asta
chalchagnol
palmeta
ferir
lanzo
45
chavo de sesto
0
corba in mezo
40
chavo de sesto
albero
antena
prova
1 scermo pianier
2 scermo postizo
3 scermo terzaruol
corsia
1 2 3
postiza
banda
zovolo
spiron
rieda
asta
porta del scandaler
fogon
banda
postiza
porta de scrivan
spiron
remi
Galia grossa
Pre Theodoro, c.1550
Misure di vascelli, 1546
0 4 8 12 16 pie
Ulrich Alertz

Fig. 32.11. Galia grossa, *1550.*

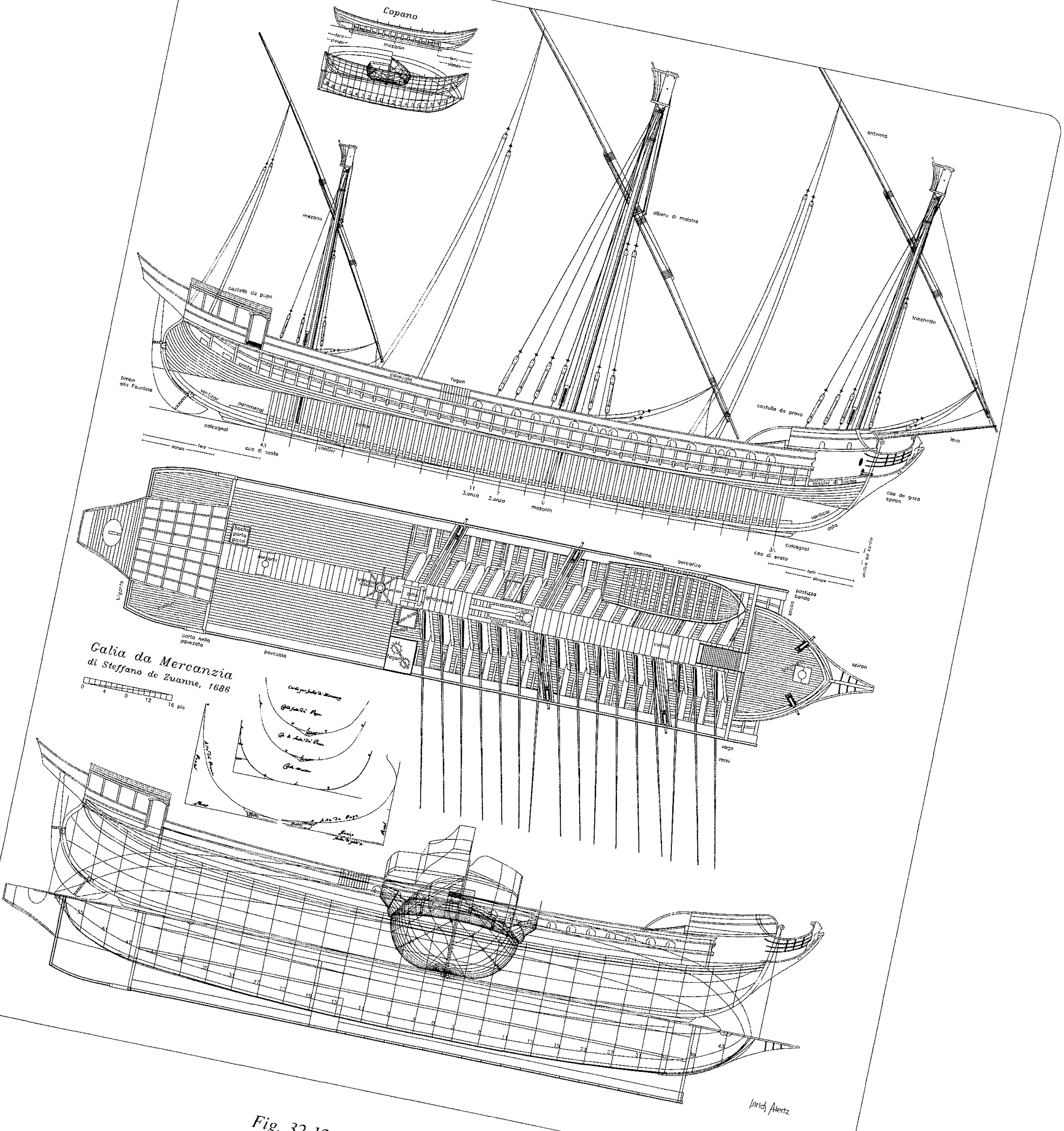

Copano
mezanin
ferir
stanze
mezana
albero di maistra
antenna
trinchetto
castello da pupa
castello da prova
timon alla Fountina
pavesata
fogon
calcagnol
cuo di sesto
mazanin
3. onza
2. onza
lovo
cao de gozo
spiron
coperta
bancarizo
postizza
bando
corsia
pavesade
porta nella pavesada
Galia da Mercanzia
di Steffano de Zuanne, 1686
0 4 8 12 16 pie
vogo
remi
Ulrich Alertz

Fig. 32.12. Galia da Mercanzia, 1686.

fols) Giorgio Trombetta da Modon, *Zibaldone* (Venice 1441–1449).

Venice, Archivio di Stato, Archivio Privato Pinelli, busta 2 (21 fols) *Misure di vascelli et cetera di ... proto nell'Arsenale di Venezia* (Venice 1546).

Venice, Archivio di Stato, Archivio Proprio Contarini 19 (39 fols) Pre Theodoro de Nicolò, *Arte de far vasselli* (copy of the Marciana original).

Venice, Biblioteca Nazionale Marciana, Manoscritti italiani, classis IV, 26 (=5131) (42 fols) Pre Theodoro de Nicolò, *Instructione sul modo di fabricare galere* (Venice *circa*1550).

Venice, Biblioteca Nazionale Marciana, Manoscritti italiani, classis VII, 379 (=7588) (21 fols) Allessandro Picheroni della Mirandola, *Disegni di biremi, triremi, quadriremi* (Venice *circa*1550).

Vienna, Österreichische Nationalbibliothek, Coll. Marco Foscarini, Codex 6391 (122 fols) *Arte de far vasselli* (16th century copy of a Venetian original of *circa*1410, almost identical with the *'Fabrica di galere'*).

Notes

[1] London, BL, Cottonian Manuscripts, Titus A.26, f.45r

[2] Florence, BNCF, cod. Magliabecchiano classe XIX, 7, f.121v; Vienna, ÖN, Coll. Marco Foscarini, Codex 6391, f.121r–v

[3] Florence, BNCF, cod. Magliabecchiano classe XIX, 7, f.4.

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Breydenbach, B., 1486, *Sanctarum peregrinationum in montem Syon ad venerandum Christi sepulcrum in Ierüsalem. atque in montem Synai ad diuam virginem et martirem Katherinam opusculum hoc contentiuum per Erhardum reüwich de Traiecto inferiori impressum in ciuitate Moguntina anno salutis. M.cccc. lxxxvj. die xj. Februarij finit feliciter.* Mainz.

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33. The Art of Designing and Building Venetian Galleys from the 15th to the 16th Century

Mauro Bondioli

The architectural study of Venetian shipbuilding in the Renaissance is ultimately based on a handful of manuscripts that describe parts of different types of ships and boats in contemporary use. The existence of these documents has been well known for a long time – in 1840, Auguste Jal dedicated *Mémoire* n° 5 of his *Archéologie Navale* to some pages drawn from the *Libro di marineria*, better known today as *Fabrica di galere* – but our knowledge remains incomplete at best. In fact, only a few of the sources have been published in modern critical editions, and only some aspects of the processes described in the documents have been investigated by scholars. There is still no convincing, comprehensive theory to explain the many aspects of ship design and construction in medieval and Renaissance Venice.

Nevertheless, the importance of these sources to our understanding of the maritime past of the Mediterranean is undeniable and the manuscripts deserve further, intensive study. In the first place, they are the only *corpus* of suitable technical documentation to come from the personal notebooks of practical shipbuilders, people in a position to supply an enormous amount of useful information. In contrast, the other historical sources, such as notaries contracts, cartularies, and chronicles, while useful as well, can only supply information of a general or contextual character. Secondly, these documents reveal the evolutionary processes in shipbuilding over two centuries that form the bridge between what we might call a traditional, late medieval attitude and a more innovative, Renaissance mindset among artisans.

It is nearly superfluous to add that an understanding of the Venetian texts would not only increase our familiarity with the construction processes used in the *Arsenale*, but would open new horizons of study in more distant places, such as the Greek islands, the origin of the best and most famous constructors of Venetian *galee sottili* in the early 15th century. Moreover, we feel compelled to emphasize that in the absence of a theoretical study of medieval/Renaissance design and construction principles, a thorough analysis of an archaeological find could only be completed with difficulty if at all. Such a find, the 14th century *galea grossa* of Boccalama, in the Venetian lagoon, has been recently investigated.

The complexity of the verbal and graphical instructions contained in the documents is one source of the difficulty in comprehending them, as is the philological problem of translation from the highly idiomatic and abbreviated medieval Venetian dialect in which they are written, but greater obstacles lie in a lack of appreciation for the medieval mindset reflected in the documents and the frequent failure to apply a rigorous enough method of research. Progress has still been made. The commendable pioneering studies of the 1800s have been complemented in recent decades by a series of detailed studies of particular problems, so that a single, traditional explanatory vision tied to an academic concept of the evolutionary progress of naval technology is increasingly related to an antithetical, more metaphysical vision wrapped in the memory of the lost secrets of the *proti*, the shipbuilding masters of the Venetian *Arsenale*.

In trying to unravel the meaning of these enigmatic documents, we have tried to follow a systematic approach, consisting of ten basic steps and starting from the primary sources.

It is perhaps appropriate to note here the manuscripts that form the core of the source material. These are:

from the 15th century:

- the aforementioned *Libro di marineria;*[1]
- the *Libro di appunti* of Zorzi da Modon, called *Trombetta;*[2]
- *Ragione antique spettanti all'arte del mare et fabriche de vasselli.*[3]

from the 16th century:

- *Misure di vascelli et cetera di ... Proto nell'Arsenale di Venetia;*[4]
- *Instructione sul modo di fabricare galee* of pre' Todaro de Nicolò;[5]
- *Disegni di biremi, triremi, quadriremi*, attributed to Alessandro Picheroni;[6]

- *Visione di Drachio* of Baldissera Drachio Quintio.[7]

To these relatively well-known sources our searches have allowed us to add a previously unknown text, which we have entitled *Modo di far galee grosse e sottili*, by Nicolò and Hieronimo Secula.[8]

From these sources, we have proceeded as follows:

1. Archival search, collection and transcription of the primary sources.
2. Cataloguing of the documentation.
   The collected documentation, integrated with smaller works and the material of the archives, has been dated and classified in relation to the period of reference of the information and to the type of represented ship.
3. Selection of the main subject of the search.
   Considering the great variety of the ship types and the discontinuity of some descriptions, it seemed reasonable to concentrate the search, before passing to other subjects, on a type of ship for which the greatest amount of information survived for each period. The work has thus concentrated on the *galea sottile*, the most common warship type of the Renaissance and a type which is present in every manuscript. It is believed that the knowledge gained from the examination of the data regarding this type can be used to interpret the more fragmentary evidence for other types.
4. "Decomposition" of the texts.
   Each sentence of each text has been divided into simple phrases, each one containing one single constructive instruction.
5. Construction of a database.
   The individual instructions have been inserted in a database and each instruction has been placed side by side with those most similar or relating to the same subject.
6. Comparative analysis of the instructions.
   The institution of the database has allowed the systematic comparison of the instructions, which has revealed various errors arising from the copying of the texts as well as common sources for some of the texts. For example, it is hypothesized that the two earliest texts, the *Libro di Marineria* and the *Libro di appunti* of Zorzi Trombetta are in fact copies of partly overlapping and partly complementary parts of a common original text.
7. Ordering of the instructions.
   The instructions, verified and corrected, have been recomposed into a new text with its structure based on the implied construction sequence.
8. Graphical interpretation via CAD.
   Finally, not without enormous difficulties, the instructions were used, with the aid of computer aided design (CAD), to develop a graphical reconstruction of a hypothetical galley.
9. Theoretical processing of the principles and methods of construction.
   Still more complex has been the translation into general principles and methods of what has been drawn. This work had to begin intuitively, then proceeded by eliminating progressively, with greater scientific rigor, the alternative possibilities.
10. Verification of the constructive theses.
    Finally, every constructional hypothesis has been tested against the data from the different texts as well as other sources, trying to confirm or refute the proposed construction sequence.

In the end, the task here consists of using certain fundamental criteria in the creation of the theoretical. In more concrete terms, any constructional hypothesis we formed had to be provable with the data from the manuscripts and be compatible with the known technology of the period. In the cases where differences could not be eliminated, an adequate justification was required. This does not mean the final result of our research represents the absolute truth, which is in fact an illusory goal, but that our hypotheses represent one possible solution based directly on the primary evidence and attained through a rigorous and systematic analysis of that evidence.

It is interesting to note that a recurring problem in the study of the documents occurs with the specific numerical values given, as these do not seem to agree with the available archaeological evidence. This leaves the researcher in even more doubt when confronted by the measurements given for the parts of ships not normally preserved in the archaeological record. Are the measurements provided in the documents the result of theoretical calculations or are they measurements taken during construction of actual ships or are they the measurements of finished ships?

If we accept that the concept of precision played a primary role in the development of ancient designs, it is obvious that to recover the definition of basic construction principles, it is essential to know the origins of the measurements taken from archaeological finds. To what degree are the excavated dimensions the result of pure or theoretical calculation and to what degree have these "pure" measurements been adulterated by the unavoidable approximation necessary during the building process or the deformation that the timbers have sustained with decay and the passage of time? Concerning the dimensional values given in the texts, while it is not possible to give a certain answer for all, it is possible that at least some of them are contemporary with the construction process, if they do not, in fact, precede it.

For example, it is only necessary to consider the occasional indications in the manuscripts for the positions in which ribbands (*maistre*) were to be placed. Ribbands, which are still used in traditional shipyards, are longitudinal battens placed over the outside of the frames (*corbe*) from stem to stern, effectively creating a sort of gridwork defining the shape of the hull.[9] These ribbands were temporary elements and were removed during construction as they were replaced by planking. As these vital elements of the shaping and construction process leave little or no visible trace, how could their location be known from finished hulls? Thus at least these parts of the manuscripts must refer to dimensions used to lay out the timbers rather than the measurements of existing ships.

In addition, there are other values that cannot be readily or easily derived from the completed ship. For example, the exact spacing of the frames amidships (*corba di mezo*) and at the ends (*qudiere corbe*) may not be readily discernible, and some fractional values, like those given in the *Misure di vascelli*, are unlikely to be obtained from real ships. The high degree of accuracy with which these dimensions are specified suggests that they are more likely the result of calculation, the product of a single will, than of physical mensuration.

In any case, research focused on the numerical data in the manuscripts, although it facilitates study of theoretical conjectures regarding the design process and provides undoubtedly valuable historical context, also forces the scholar to work in an artificial atmosphere. This is a plastic world of numbers, straight lines and mathematically pure curves, far from the truth of the shipyard. In order to reduce the latter disadvantage and to reach a conclusion of relevance to the construction of actual ships, our theoretical results have been subjected to practical testing. In other words, each timber's proposed definition by the terms of the manuscripts has been tested by physical experiments in constructing that timber in scale model form. Where doubts have arisen, it has been necessary to return to the primary sources in order to verify that there are not alternative interpretative possibilities.

It has also become apparent that some of the section curves generated by the primary data are too rigid and "sour," and, without upsetting the course of the research, have to be softened somewhat in order to obtain more harmonious lines in agreement with general principles of shipbuilding.[10] It is clear from these quirks as well as from other sources that the shipwrights in the yard did not apply the "rules" of the manuscripts in an absolutely rigorous fashion, but used them as a general guide or "first approximation," liable to change in the course of building. Where thus a modern CAD program will draw a perfect mathematical curve, the shipwright sketched a less sensitive curve with his axe and then adjusted it until it was sweet to his practiced eye.

As can be seen, research into the Venetian shipbuilding manuscripts involves many complex and interwoven issues. Certain results are difficult to attain, and the research is far from concluded. Our work will continue in the immediate future with the practical testing of our hypotheses through the construction of a series of scale models reproducing the original moulds.

The space available for this contribute does not permit a detailed presentation of the entire process as we believe it to have been practiced in all its variations in the 15th and 16th centuries. Instead, as an example of the results of our work so far, we offer a short summary of the major aspects of the construction sequence for a *galea sottil.*

Construction sequence of a galea sottil

After the construction of a solid base (a series of posts fixed in the ground and braced by long stringers called *maistre*), the total length of the galley is determined with the aid of a cord (*trizuola*) stretched taught between two external staves (Fig. 33.1).

On these staves are marked, with a star (*posselese* of the *coltro*), the rakes (*lanzi*) of the upper part of the stem and sternpost. The curve of the keel (*colomba*) is defined by the catenary of a slack cord fixed at different heights to the end staves (Fig. 33.2).

A series of beams (*cantier*) to support the keel are set up following the curve defined by the cord (Fig. 33.3).

On these beams, a series of staves are placed at the points where the three key frames will be erected: the amidships frame (*corba de mezo*) and the so-called tail frames, the frames near the inboard ends of the stem and sternpost (*qudiere corbe*). On the amidships stave, the height of the sheer is marked. The same height is marked on the forward stave, while a greater height is marked on the after stave. Then the same method as was used to define the curve of the keel is used to define the curve of the sheer, with the ends of the slack cord fastened to the end staves at heights that allow the cord to cross the sheer heights marked on the three key frame staves. This simultaneously defines the heights of the stem and sternpost (Fig. 33.4).

At the bow and stern, where the rake is marked, the terminal sections of the keel curve (which are of slightly different shape than the main keel curve) are defined with the aid of a rod (*morello*) placed at regular intervals. This rod is depicted here in several locations in order to show the process of definition (Fig. 33.4 bis).

The curves of the stem and sternpost are defined with the aid of cords (*valangin*) and the afore-mentioned rods (Fig. 33.4 ter).

With the curvature of the longitudinal structure of the galley defined, the timbers of the keel and posts can be fabricated and set up on the stocks (Fig. 33.5).

On this backbone, the locations of the frames are marked, with every fifth frame (*corbe de onza*) specially indicated. Using the same staves as were used to define heights of the key frames (shown here in greater number only indicate the sequence of construction), the heights of the intermediate frames as well as the rising (*stella*) of the floor is marked. The latter is defined by the curve of a slack cord grazing the keel amidships (Fig. 33.6).

The amidships frame and the tail frames of the bow and stern are fabricated (based on another series of measurements) and set up (Fig. 33.7).

Finally the intermediate frames (every fifth frame) are set up (Fig. 33.8).[11]

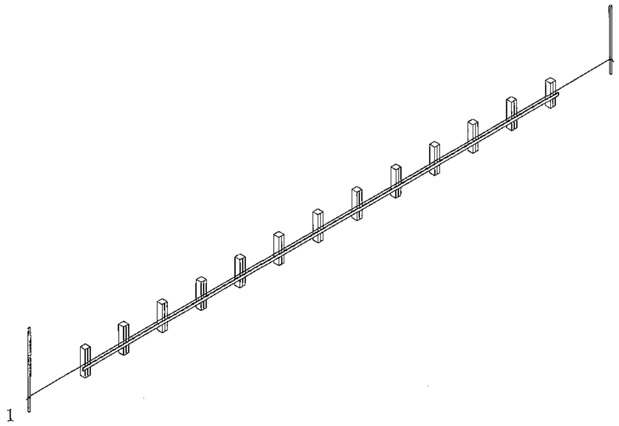

Fig. 33.1. After the construction of a solid base (a series of posts fixed in the ground and braced by long stringers called maistre*), the total length of the galley is determined with the aid of a cord (*trizuola*) stretched taught between two external staves.*

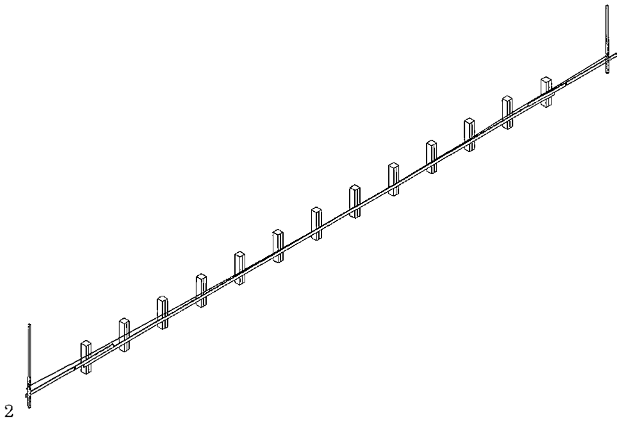

*Fig. 33.2. On these staves are marked, with a star (*posselese *of the* coltro*), the rakes (*lanzi*) of the upper part of the stem and sternpost. The curve of the keel (*colomba*) is defined by the catenary of a slack cord fixed at different heights to the end staves.*

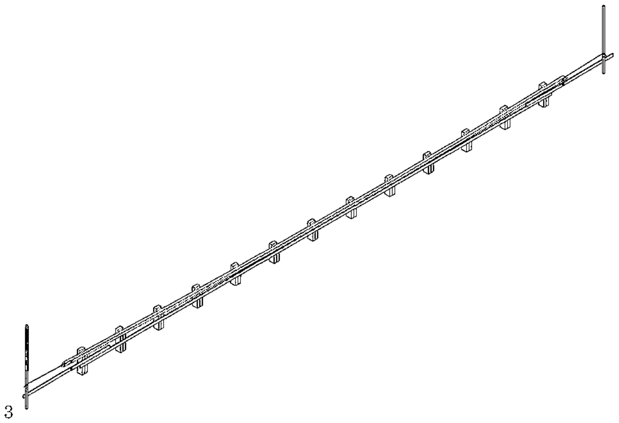

*Fig. 33.3. A series of beams (*cantier*) to support the keel are set up following the curve defined by the cord.*

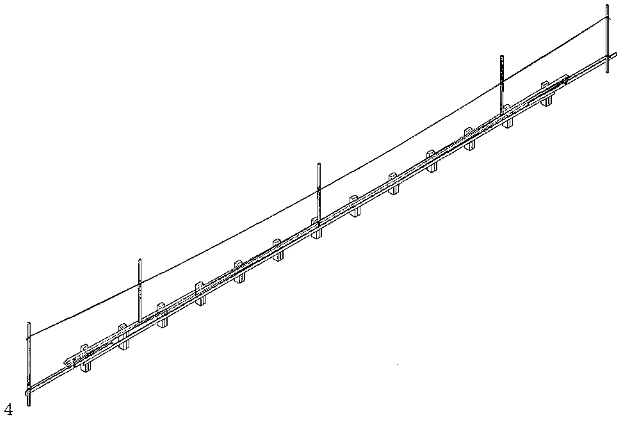

*Fig. 33.4. On these beams, a series of staves are placed at the points where the three key frames will be erected: the midship frame (*corba de mezo*) and the so-called tail frames, the frames near the inboard ends of the stem and sternpost (*qudiere corbe*). On the midship stave, the height of the sheer is marked. The same height is marked on the forward stave, while a greater height is marked on the after stave. Then the same method as was used to define the curve of the keel is used to define the curve of the sheer, with the ends of the slack cord fastened to the end staves at heights that allow the cord to cross the sheer heights marked on the three key frame staves. This simultaneously defines the heights of the stem and sternpost.*

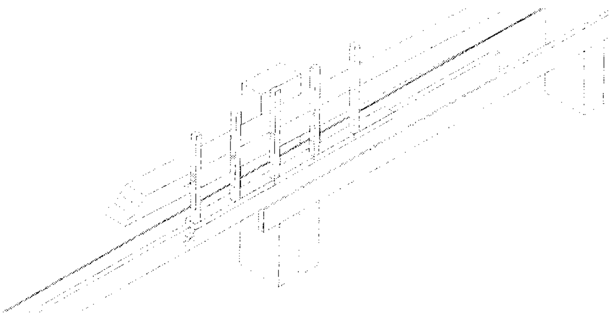

*Fig. 33.4 bis. At the bow and stern, where the rake is marked, the terminal sections of the keel curve (which are of slightly different shape than the main keel curve) are defined with the aid of a rod (*morello*) placed at regular intervals. This rod is depicted here in several locations in order to show the process of definition.*

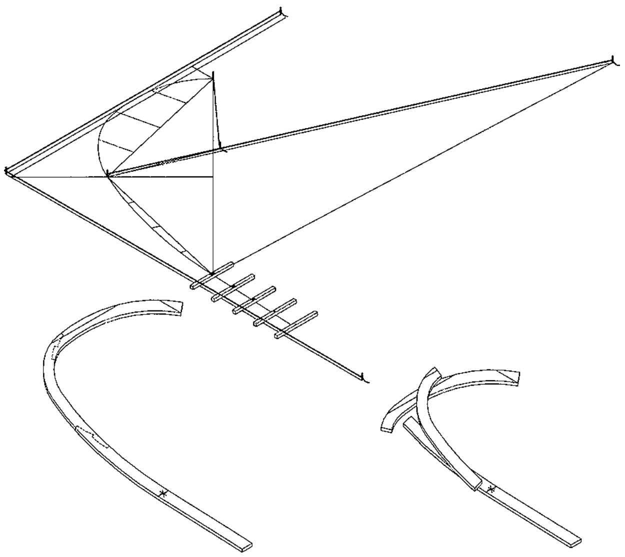

*Fig. 33.4 ter. The curves of the stem and sternpost are defined with the aid of cords (*valangin*) and the aforementioned rods.*

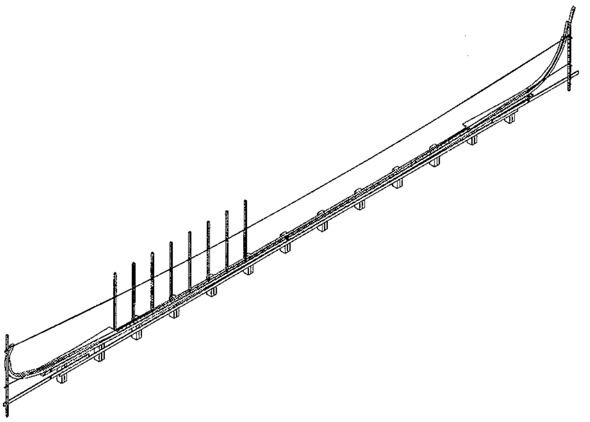

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*Fig. 33.6. On this backbone, the locations of the frames are marked, with every fifth frame (*corbe de onza*) specially indicated. Using the same staves as were used to define heights of the key frames (shown here in greater number only indicate the sequence of construction), the heights of the intermediate frames as well as the rising (*stella*) of the floor is marked. The latter is defined by the curve of a slack cord grazing the keel amidships.*

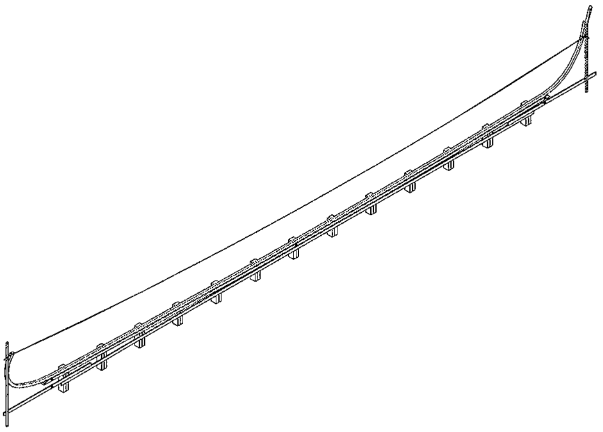

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Fig. 33.5. With the curvature of the longitudinal structure of the galley defined, the timbers of the keel and posts can be fabricated and set up on the stocks.

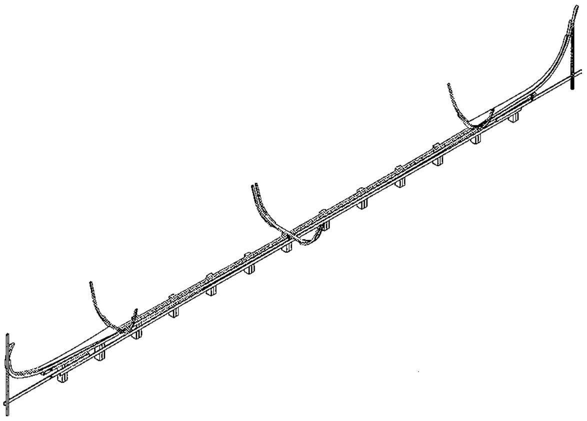

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Fig. 33.7. The midship frame and the tail frames of the bow and stern are fabricated (based on another series of measurements) and set up.

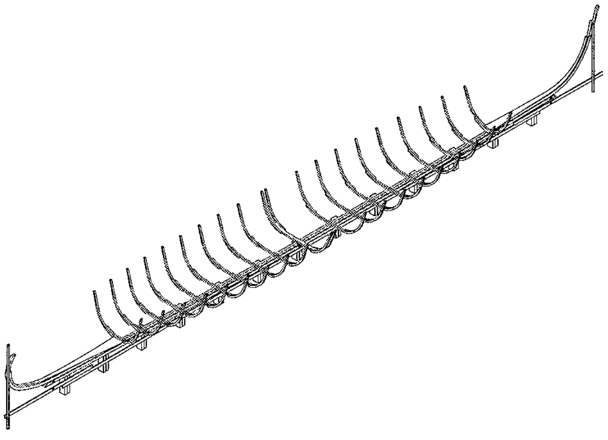

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Fig. 33.8. Finally the intermediate frames (every fifth frame) are set up.[11]

This effectively ends the process of predetermination of hull shapes. The remaining timbers are cut to fit this preliminary structure, with the remaining frame shapes determined with the help of battens or ribbands run over the intermediate frames.

Even though this construction sequence is limited and incomplete for the reasons described previously, it is necessary to state clearly that the complete sequence was not repeated in every instance that a new ship was built. It was sufficient to carry the entire sequence through to completion one time alone and then record the significant increments and measurements on wooden tablets designed for that purpose or directly on the moulds/patterns. It is likewise necessary to highlight that every shipwright introduced his own personal variations. Some masters suspended a single length of cord in correspondence to the depth of hold, while others used a second length of cord at the height of the wale (*centa*).

In the course of the sixteenth century, among the many and various innovations, the ancient method of using lengths of cord to define the profiles of the curves was abandoned. Simple methods of geometric reductions (or even algebraic ones in the case of Vettor Fausto), similar to the reductions employed in the fifteenth century to calculate the narrowing of the frames, were substituted. The use of rods to determine the intermediate heights of the rising line (*stelle*) disappeared as well. Therefore, a good deal of the information contained in the fifteenth-century texts dealing with these systems was no longer considered necessary. When drafted, the manuscripts on shipbuilding, then, were shortened. Nonetheless, even with fewer data, they are no easier for modern scholars to interpret.

Acknowledgments

Many thanks to Frederick M. Hocker who corrected this paper with important suggestions. Many thanks to S. Bellabarba, F. Ciciliot, J. Mac Manamon, G. Penzo, A. Rosada, F. Rossi and P. Rossi for useful informations.

Notes

[1] Biblioteca Nazionale, Florence, ms. Magliabechiano, cl. XIX cod. 7.

[2] British Library, London, Cotton ms., Titus A XXVI.

[3] National Maritime Museum, Greenwich, NVT 19.

[4] A.S.V., Archivio Proprio Pinelli, b. 2.

[5] Marciana National Library, Venice, ms. it., cl. IV cod. 26 (5131).

[6] Marciana National Library, Venice, ms. it., cl. VII cod. 379 (7588).

[7] A.S.V., Archivio proprio Contarini, b. 25.

[8] A.S.V., *Memorie antiche che possono supplire ai vacui dei Commemoriali*, vol. I, 186–188.

[9] The ribbands are also used to assess hull curvature and to help locate places where small adjustments are necessary in order for the planks to run fair.

[10] This manual fairing of theoretical section curves can be seen directly in the sections drawn by Mathew Baker for his treatise of the 1580s.

[11] The narrowing of the frames is determined by one of a variety of geometric methods.

34. Reportage, Representation and Reality. The Extent to which Chronicle Accounts and Contemporary Illustrations can be relied upon when discussing the Tactics used in Medieval Galley Warfare

Susan Rose

Medieval accounts of sea battles are very often sparse in the extreme. We are left with the bare statement that so many ships were taken or that others fled and our final impression is that both tactics and strategy were undeveloped. The only perception commonly held by many modern historians seems to be that the one concern of a medieval shipmaster or commander was to recreate, as closely as possible, the conditions of land warfare at sea. In order to begin the re-examination of medieval naval tactics and the possible rejection of this preconception, this paper will look more closely at one particular feature of chronicle accounts of sea battles, and also at the details of certain pictorial representations. An attempt will then be made to assess their worth as evidence.

The most unnerving situation for the master of any vessel is to find him or herself 'drifting helplessly'. To find oneself unable to direct or control the course of a ship, or to influence its speed in any way, is to leave the vessel and its unfortunate crew at the mercy of wind, tide and currents. This applies as much to the largest and most technologically advanced modern 'bulk carrier' as it does to the most primitive craft of earlier times. Even in a snug harbour on a fine summer's day, if a boat's mornings are inadvertently loosed and it begins to drift, the result will be confusion and chaos, whether on the quayside or on the boat itself. Nevertheless it has been widely accepted by naval historians, basing themselves largely on accounts in contemporary chronicles, that a tactic frequently employed by fleets (largely but not exclusively of galleys), before battle was joined, was to lash the vessels together to form a kind of fighting platform.[1]

If the galley masters did this in fact, it is hard to imagine how they would then be able to manoeuvre or control their vessels. The oarsmen would have been more or less obliged to ship their oars. The tangle of ropes or cables, dragging perhaps under hulls or snagging other fittings, can easily be imagined. Collisions between adjacent vessels would be only too likely and in any kind of sea all these problems would rapidly become worse. Should the tide of battle turn against a group of galleys lashed one to another, flight by even a single vessel might well be impossible. Here seems to be a problem needing investigation. Is there an inherent conflict between what one might call the 'common sense' of seafaring and the records of medieval sea battles? To attempt to resolve this problem, we need to try and establish when this tactic was first described. Did it only occur in certain circumstances? Is there any other evidence, whether written or visual, for this practice apart from that in the chronicles which were usually written some time after the event by authors with very little experience of the sea? Was the tactic found only in galley actions in the Mediterranean or could it also be found in northern waters? In short, can a more plausible account of the tactics employed by the fighting commanders of medieval ships be extracted from the often unsatisfactory sources at our disposal?

Some of the most striking evidence for this practice comes from accounts of the naval element in the war of the Sicilian Vespers and the career of Roger of Lauria. The battles of Lauria, who was fighting on behalf of the House of Aragon, particularly Peter III, against the Angevins, are well recorded in chronicles, particularly that of Ramon Muntaner, a Catalan who claims to have direct experience of naval warfare in his writings (Muntaner, 1920–21: 330). They have also been studied by John Pryor in an article in the Journal of Medieval History (Pryor, 1983) while the battle of Malta in 1283 in particular is the subject of a chapter by L. V. Mott in Kagay and Villalon's *The Circle of War in the Middle Ages* (1999). The outline of events at Malta is fairly clear; the Angevin forces held the castle (now the Castel St. Angelo then known simply as *Castrum maris*), but were under attack from the landward side by the Aragonese. Lauria arrived with his fleet off the Grand Harbour and carried out a successful scouting operation, sending a boat with muffled oars into the harbour during the hours of darkness. As a result of the intelligence collected, he seems to have adopted the strategy of abandoning the benefits of surprise in favour of luring the Angevin galleys away from their secure position, beached under the castle walls, out into the main basin of the harbour. After Lauria had roused his enemies with trumpet blasts, the chronicle then states, 'they (the galleys of Aragon) began to enter the harbour, formed in line and all galleys lashed together' (Muntaner, 1920–21:191). Pryor (1983:179) elaborates this saying 'Lauria bridled his galleys together with their oars lashed across from one to another so as to form an impenetrable line across the exit from the harbour'. Mott (1999: 157) speaks of heavy cables being passed from one galley to another, 'so that enemy ships could not pass between them'. He also denies that this was primarily a defensive tactic and talks of ships being placed 'in an open formation so that their oars were clear' and of the heavy galleys rowing forward as a unit with the light galleys and armed *lenys* forming a 'mobile reserve behind the cabled galleys.' Both Pryor and Mott state that the tactic of lashing or bridling galleys together was a tactic developed by the Genoese sometime in the 12th or 13th centuries but without providing evidence for this. Leaving this aside for the moment, there are still difficulties with these accounts. Muntaner talks of the Aragonse advancing to join battle. The implication must be that the galleys were under oars. How can this be reconciled with lashing oars together as Pryor suggests? Pryor also describes the bridles as being cut free once opposing vessels moved in to grapple each other or attempted to flee but Muntaner makes no mention of this. What he does describe, after the Angevin forces, responding to Lauria's trumpet calls, had left their anchorage and advanced under sail, is a violent clash in the middle of Grand Harbour; 'they came to attack so vigorously that the prow of every galley was shattered'(Muntaner, 1920–21:192). This seem to imply that the opposing galleys were driven into each other bow to bow with the boarding parties eventually pouring over the beak into a confused melee of the dead and the dying. Muntaner makes plain the severity of the bombardment of crossbow bolts, darts and other missiles which the Catalans launched at their opponents. Boarding does not seem to have taken place until most of the Angevin forces were dead, including the admiral Cornut and other officers.

Another engagement this time off the Costa Brava, in 1285, further illustrates the problems raised by the possible lashing together of galleys. Two Aragonese commanders Ramon Marquet and Berenguer Mallol with eleven galleys and two lenys got good intelligence of the number and deployment of the French galleys supporting Philip III's of France's invasion of Catalonia.. They came up on the twenty-five French galleys commanded by Guillaume de Lodéve near las Rosas at dawn. Muntaner (1920–21:329) describes him, as advancing under sail with, 'fifteen galleys lashed together and ten astern following in the intervals between them in such wise that none could escape them.' Mallol and Marquet likewise 'had their galleys lashed together with long ropes and they made fast all the oars with long ropes in order that the enemy should not be able to get between them......until they loosened the oars and came to a hand-to-hand fight' (Muntaner, 1920–21: 330). After the Catalan crossbowmen had almost cleared the decks of their opponents by the accuracy and ferocity of their fire, the signal was given by Mallol and Marquet, 'everyone should ship the oars and go amongst the enemy'. The result of the final stage of the battle was complete victory for the Aragonese. The detailed discussion of this battle by Mott does not question the practicality of lashing galleys together in battle. He describes the tactic as producing 'a large floating fortress', (another reference to the idea of sea battles as land ones) and speaks of the defenders being able to 'transfer men from one ship to the next to beat back any assault' (Mott, 1999: 169), not perhaps an easy thing to accomplish at sea when under attack.

The first battle at Malta did take place in the very sheltered waters of the Grand Harbour, but even so a line of around 22 galleys lashed side by side (but far enough apart for their oars to be clear), initially in its comparatively narrow entrance, would have been in grave danger of grounding at its extremities. Las Rosas is situated at the back of a deep bay but the surrounding coast is rugged; in summer the prevailing wind is from the north west, that is off-shore. The current sets south along the coast so that drifting vessels would tend to move towards the cliffs on that side of the bay or towards Palafrugell. The initial crossbow phase of the engagement seems to have lasted some considerable time so that the amount of drift (if we accept the lashed platform scenario) might have been considerable. The 'fortress' would have been perhaps in greater danger from going on the rocks than from the enemy. There is also the problem of how the Catalan galleys advanced to meet the enemy if their oars were lashed together since it was clearly the normal practice to lower the masts and sails before action. An even greater problem is posed by Muntaner's (1920–21:329) claim that the French commander came out with lashed galleys under sail with the intention of keeping the action away from the confines of the bay. This is a reasonable aim but to proceed under sail alone with fifteen vessels attached one to the other seems a recipe for chaos. If we abandon the notion of lashed oars in the case of the Catalans and accept the idea of loose cables between the galleys there are still some difficulties. Galleys under oars would have to maintain quite some distance between each other to avoid damaging clashes and breaking oars; the cables would surely trail in the water. Muntaner's description of the galleys advancing 'poop by poop' with their crossbowmen loosing a withering fire on the French carries some conviction but he may possibly not have understood that skilled shiphandlers could keep a vessel on station more easily without the presence of lashings and cables than with them.

There is also the question mentioned above of the origin of this practice if it existed. Something similar can be found earlier than the 12th century. Is this a case of chronicle writers describing sea battles, as they ought to be, following classical models? Anna Comnena in the Alexiad mentions the Venetians using a defensive formation called a sea harbour on two occasions; once off

Durazzo and once in the harbour at Corfù in 1082 when under attack by Robert Guiscard (Comnena, 1969:138, 190). This involved at Corfù linking the larger vessels with iron chains in a circle with the smaller vessels on the inside but again there was no intention of any ships moving. Her account of the actual fight mentions the ships colliding head on with many men drowning from capsizes, as the ships were not in ballast or carrying cargo. It should be noted however that these events occurred before her birth and we have no knowledge of the source of her information (Anna Comnena, 1969: 190). A French commentator at the time of the Revolution (Legrand d'Aussy, n.d.: 30) pointed to a reference in Livy's account of the War against Hannibal which seemed to imply something similar to the rafting up of galleys. However the reference is to transport vessels supporting the siege of Tunis during the Punic wars not to fighting between ships. The Roman vessels were drawn up in lines four deep in front of the city wall with the masts and yards laid across from one ship to another. They were not expected to move but to be, as it were, pontoons for the attacking forces, a fighting platform certainly but not one involved in a sea battle (Livy, XXX, 10. trans. 1965: 628–630). Livy in fact remarks that, 'what followed had no resemblance to a sea fight.'

Vegetius, the author of the very influential text, *Epitome Institutionum Rei Militaris*, written some time after 375 AD has something to say on naval tactics but does not mention this stratagem. He talks of the benefits of deploying a fleet in a crescent shape so that the opposing fleet may be enfolded in the 'wings'. He describes weapons which he claims are peculiar to fighting at sea, including a kind of flail fixed to the mast which could be rotated and thus cut the enemy's rigging. He is very much aware of the need for good intelligence at sea but does not advocate anything like the lashing together of warships going into battle (Vegetius, IV, 31). Livy's comments may possibly have been misinterpreted by later medieval writers, as Legrand d' Aussy implies, but there does not seem to be a strong classical tradition among classical writers relating to this practice.

It is, however the case that the practice can also be found in descriptions of battles in northern waters. The *Heimskringla* or lives of the Norse kings includes descriptions of rather similar tactics, involving the cabling together of boats in eleventh century Viking battles but this work itself dates from the early 13th century which may affect our view of its reliability. In a battle between the forces of Harald Hardraada and Swein in 1062, the saga tells how 'both sides roped their ships together in the midmost parts of their fleets.' But it goes on the explain that because of the number of vessels involved, 'there was a great number of ships which went loose' [that is did not form part of the roped together sections] 'and each one put his ship as far forward as he dared; thus there was much uneveness' (*Heimskringla,* n.d.: 544). The general tactics of the battle do not differ greatly from those used in the Mediterranean, showers of missiles followed by boarding. This encounter, however, was not located in the open sea but in an estuary. The account also makes it plain that it was the so-called 'loose ships' that largely decided matters in favour of Hardraada and that the crews of those ships still roped together faced great problems in fleeing to safety. The 'roped ships' here seem to have been intended to form a solid core for fleets engaged only just off-shore but the reference to 'unevenness' again raises the possibility that what is really at issue is the ability of ships to maintain their station in a line abreast.

There are also accounts of later battles in northern waters which include mention of the lashing together of warships. A rhymed description of the battle of Zerickzee between the Flemish and the French in 1306 includes the information that the advancing French fleet attached each ship to its neighbour with cables. This is stated to be in order to prevent them losing their formation despite the action of the tide or the winds. The battle itself, however was a hard-fought and complex affair with the 'cabled' squadron playing little part until the ships could manoeuvre freely (Legrand d'Aussy, n.d.: 9–18). The French commander at the much better known battle of Sluys in 1340, if we accept the statements of some of the chroniclers, adopted a similar tactic. The French fleet was chained together into one line so that, we are told, the English ships could not get between them (Rose, 1994: 28–29). To adopt such a tactic in the Zwyn on a flood tide and with an on-shore wind seems extremely dubious seamanship in view of the many shoals and sandbanks in the estuary (de Vries,1995:227).[2] It may well be that the tactic appealed more to chroniclers familiar with earlier accounts of sea battles than to the masters of warships.

If we turn to visual evidence for medieval sea fights different problems arise. We can take the example of the battle of Zonchio which is described by both Domenico Malipiero, present as one of *provveditori del armata,* in his Annals for the years 1457–1500 and also by Sanudo in his diary(Sanudo II, ed.1969–70: 1230–1241). It is also the subject of a large and beautiful woodcut in the British Museum (Fig. 34.1). This was produced shortly after the conflict itself and its existence perhaps reflects the amount of contemporary interest in an engagement which was a disaster for Venice. It might be assumed that a picture like this would be better evidence of the tactics used in naval warfare than the often purely decorative pictures in manuscript chronicles. Among these are those made for a French edition of Froissart's chronicle in the 15th century, which is now in the Biblioteque Nationale in Paris. These include representations of the battle of Sluys and also an action off Guernsey in the 1350s. Although they are beautiful examples of the art of manuscript illumination, they clearly have little real value as evidence except perhaps making plain the gross overcrowding on almost all medieval ships. To return to Zonchio, however, Malipiero's account begins with the fleet orders issued by Grimani the overall commander of

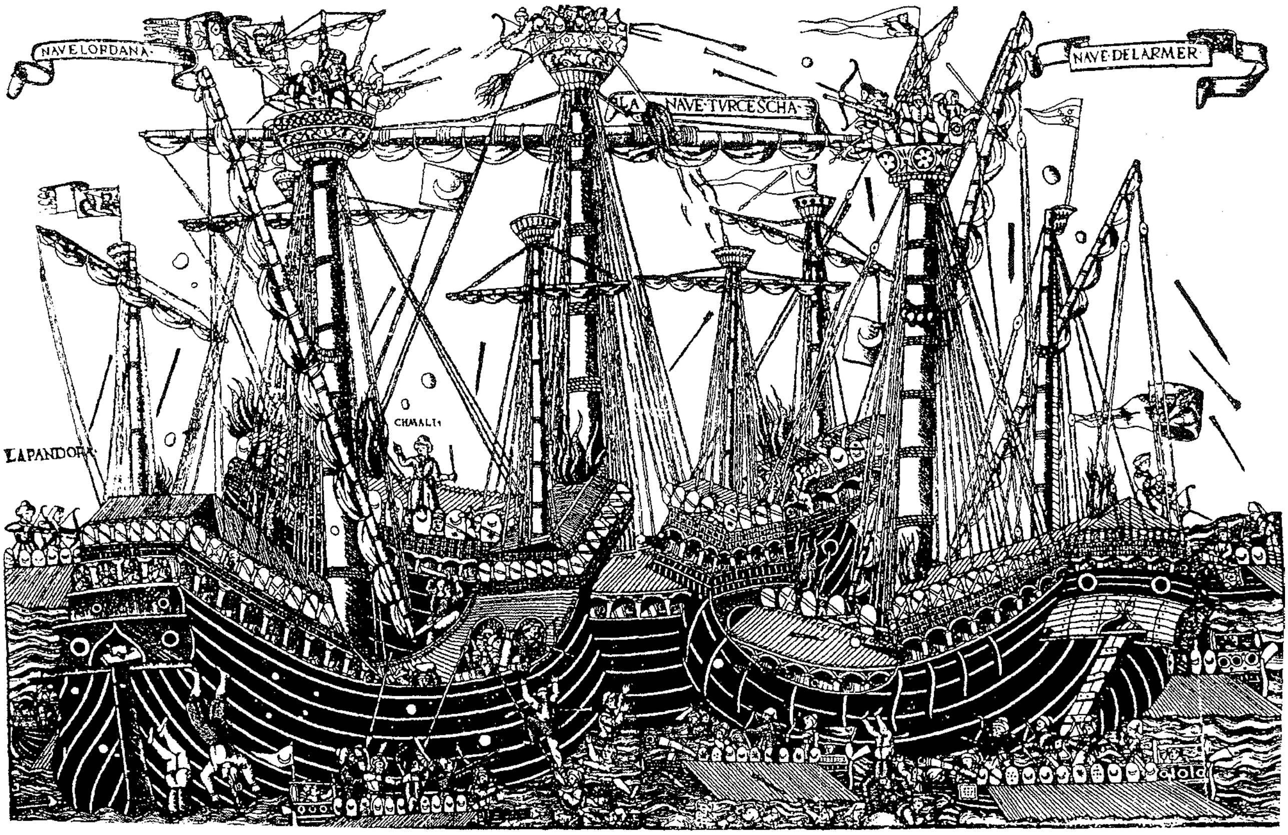

Fig. 34.1 The battle of Zonchio, 1499, a near contemporary wood-cut, a copy of which is in the British Museum.

the Venetian fleet. These disposed the fleet in three squadrons with a further fourth group commanded by Malipiero himself to give aid where required. Quite contrary to the tactics we are asked to believe were followed two hundred years earlier by Lauria and his contemporaries, the detailed orders for the galleys mention particularly the need for them to keep on station, to avoid at all costs accidental collisions and the consequent breaking of oars. Malipiero then makes the significant comment that the Venetians would have won if they had had greater courage when attacking (Longo, 1843:175–9). A sea battle was usually won or lost at this date by the elan with which the final boarding was undertaken. The one galley which did fight with vigour beat off attacks from the Turks and eventually withdrew under sail in the direction of Modon. The episode which is represented in the woodcut is not the galley action, but the encounter between a great ship of the Turks commanded by Chemali (in the Italian version) or Katib Chelebi (in the Turkish), and two large Venetian sailing ships the Pandora (commanded by Andrea Loredan) and that commanded by Albano Armer. These are all identified on the woodcut. The armament shown on the various ships has been carefully examined by Giovanni Santi Mazzini in a note in the Mariner's Mirror for February 1999. He has pointed out features of the hulls and rigging which seem to be represented with care and also the details of the weapons on view. However in some respects the woodcut is oddly lacking. All three sailing ships represented have all their sails neatly furled. If this were really the case, which seems completely unbelievable, they would have been incapable of any form of controlled movement, not a happy position to be in, in the throes of a boarding action. Malipiero also specifically mentions the wind strengthening and thus allowing the attack to commence. He also mentions the fact that Armer hoped to be supported by the captain general (Grimani) but Grimani only fired his guns and then bore away to port, away from the battle towards the open sea. There is no attempt at all to convey the confusion and terror of battle nor the effects of action at close quarters in the woodcut. Disaster in fact overtook both the Venetian and the Turkish great ships when fire engulfed them all. Malipiero states that the fire began accidentally and then spread to the other vessels (Longo, 1843: 175–179). The wood cut, as Santi Mazzini points out, shows quite a collection of incendiary weapons (Santi Mazzini, 1999: 89). These are very obvious in the original which has some colouring including scarlet for all the fire pots and the like. However no written sources mentions the deliberate use of the so-called Greek fire or other fire-raising tactics, or in fact any thing beyond the fact that all three ships were burnt to the waterline. The letter about the battle included by Sanudo in his diary does not differ greatly but implies that the fire may have been set by the Venetians after they had grappled with not one but two Turkish ships. The outcome was the same in that Chemali's vessel and the Pandora and Armer's ship were destroyed(Sanudo II, Ed. 1969–70:1233).

So where does this leave us? It seems to me that if we are to attempt to understand medieval battles at sea we can never rely on only one kind of evidence. Understanding must come from a process not unlike that of doing a jigsaw puzzle. Underlying any recorded evidence whether written or visual must be an appreciation of the realities of seafaring. Some change little over the centuries; the power of a storm is not lessened by modern technology nor is the need for seamanship removed. The configuration of the coast and the patterns of the winds and currents equally are not subject to much change. The sailing qualities and the possibilities of a vessel depend very much on its design and here 'documentary' historians like myself are in the hands of archaeologists and technical experts. Perhaps in the end the building of a replica (as happened with the Greek trireme) may be the only way to understand more about the operation of galleys or indeed the large sailing ships of the late medieval period. If, however we rely only on chronicles or read too much into pictures we may find ourselves some way from the undoubtedly confused, messy, bloody truth of medieval naval warfare.

Notes

[1] In this way it is implied the conditions of a land battle would be almost replicated.

[2] All the commentators agree that the English fleet advanced from the North West with both wind and tide in their favour.

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35. Les Galères de la Vue de Venise de Jacopo de Barberi (1500)

Lucien Basch

"Depuis 1500, des centaines de vues de villes en perspective ont été réalisées, mais aucune n'a pu rivaliser avec l'ensemble presque illimité des aspects divers de la Vue de Venise en 1500 attribuée à Jacopo de Barbari," (Links, 1972: 89). Cette Vue, objet de très nombreuses publications, a été utilisée, et le sera encore longtemps, pour l'histoire de la topographie, de l'urbanisme et de l'architecture de Venise. En outre, elle montre Venise dans toute sa gloire: en 1495, «Venice was… the outstanding naval power of the Mediterranean and the strongest state in the Italian peninsula», a écrit l'un des plus grands historiens de la Sérénissime (Lane, 1973: 237). Cependant, la Vue présente encore des énigmes qui sont loin d'être résolues. Certes, il existe une parfaite unanimité quant à la beauté et la majesté de la composition, l'extrême réalisme des représentations et la minutie de l'exécution, mais des incertitudes demeurent quant aux modes d'exécution, au but poursuivi par l'auteur et même quant à l'identité de l'auteur.

À ma connaissance toutefois, les dizaines de bateaux et de navires qui animent le port et la lagune ou s'alignent au long des quais n'ont jamais fait l'objet d'une étude systématique. Peut-être n'ont-ils pas été jugés dignes de l'être: parmi les meilleurs connaisseurs de la Vue, T. Pignatti n'écrit-il pas: «sull'acqua, anche le barchette hanno piuttosto funzione di didascalia per indicare le lagune e i canali, che non vero carattere vedutistico» (T. Pignatti, dans: Mazzariol, Pignatti, 1962: 10). Ce manque d'intérêt ne laisse pas de surprendre: certes, une vue de Venise dépourvue de navires serait fort étrange, mais la «flotte» de Jacopo de Barbari semble offrir toutes les qualités documentaires qu'on lui reconnaît généralement lorsqu'il représente les édifices de la ville: réalisme et méticulosité.

Des trois questions: qui est l'auteur?, comment a-t-il procédé? et dans quel but?, la dernière est la plus intéressante pour notre propos.

L'éditeur de la Vue, Anton Kolb, marchand allemand établi à Venise, adressa en 1500 à la Seigneurie une supplique par laquelle il sollicitait un privilège d'exploitation et une exonération fiscale; il justifiait sa demande en insistant sur l'excellence de l'œuvre et sur le fait que sa réalisation avait demandé trois ans (Kolb ne mentionne toutefois pas le nom de l'auteur); la Seigneurie accorda, le 30 octobre 1500, un monopole d'exploitation d'une durée de quatre ans. Quel pouvait être le but de Kolb en finançant une œuvre aussi gigantesque? G. Mazzariol suggéra en 1962 que la Vue était destinée à servir de plan-guide pour les visiteurs de Venise (Mazzariol dans: Mazzariol, Pignatti, 1962: 6), ce qui est exclu. En effet, la Vue, une xylographie, exécutée sur six tables de bois de poirier de 66 × 99 cm environ, mesure au total 2,818 m de long sur 1,345 m de haut, ce qui rend l'emploi envisagé pratiquement impossible. De plus, il semble que l'usage, qui nous est familier, d'un plan pour se guider dans une ville était étranger à la mentalité d'un voyageur de la fin du 15^{e} s., qui disposait d'autres points de repère.

L'hypothèse la plus probable est que Kolb a voulu publier une œuvre d'art qui exalte la gloire de Venise: il utilise les mots «ad fama» dans sa supplique et les devises latines qui accompagnent les deux divinités tutélaires de Venise sur la Vue, dont les figures se voient, symétriques, à peu près au centre, l'une en haut, Mercure, l'autre en bas, Neptune, peuvent être traduites respectivement par «Moi, Mercure, resplendis sur cette cité qui l'emporte sur tous les autres emporia» (ou places commerciales) et «Moi, Neptune, réside ici, apaisant les eaux de ce port». Voilà donc Venise glorifiée tant en sa qualité de cité et de port marchands par excellence, ce qui explique tout l'intérêt porté à la représentation des navires, si abondants: il ne s'agit ni d'ornements graphiques, ni de remplissage.

La question du «comment?» est des plus débattues. On peut, avec P.Falchetta (Falchetta, 1999: 75), distinguer deux «écoles»:

1. Selon G. Mazzariol (1962), il y aurait lieu de distinguer trois étapes: d'abord l'établissement d'un schéma cartographique général, obéissant aux lois strictes de la perspective, ensuite une série de «reliefs planimétriques» partiels, œuvres de divers techniciens

travaillant sur le terrain. C'est sur ce matériel préparatoire et disparate que Jacopo de Barbari serait intervenu, pour l'unifier, le reporter sur le schéma général et transférer le dessin final sur le bois, pour ensuite le graver.

2. Cette théorie a été battue en brèche en 1978 par Juergen Schulz dans un important article (Schulz, 1978). Cet auteur a récemment maintenu son point de vue: Schulz: 1999). Cet auteur considère que le «schéma général préalable», première étape selon G. Mazzariol, était absolument irréalisable sans appliquer la triangulation, notion encore absolument inconnue à Venise à l'extrême fin du 15^es. (Schulz, 1978: 436). J. Schulz estime que l'auteur a procédé en grande partie de façon empirique, en assemblant sur sa table à dessin une mosaïque constituée par une «myriade» de petites vues particulières s'organisant à partir de points de vue élevés de la ville, en fait: des campaniles (Schulz, 1978: 439). L'assemblage de ce puzzle géant devait se faire sur la base d'un «modello» préalable, qui ne relevait pas d'une stricte perspective scientifique. Après que l'auteur du dessin final eut appliqué celui-ci sur les bois, la gravure proprement dite aurait été exécutée par des professionnels.

J. Schulz a fait une observation d'une importance capitale: le «modello» favorisait manifestement la partie droite de la vue au détriment de la partie gauche,[1] au point d'entraîner de très graves distorsions dans cette dernière partie, où l'auteur a dû procéder «par compression». J. Schulz cite notamment l'omission de plusieurs *calli* (rues) dans les paroisses de San Bartolomeo, San Zulian, San Giovanni Crisostomo, Santa Marina, Santa Sofia, l'omission de nombreuses maisons des *campi* (places) de San Giovanni Crisostomo, Santa Maria Nuova, San Barnaba et Santa Maria Formosa ainsi que des erreurs d'emplacement de maisons en ces lieux; J. Schulz signale encore, parmi d'autres erreurs, une exagération générale des hauteurs des édifices par rapport à leur largeur et leur profondeur et diverses déformations des bâtiments dont la liste serait trop longue pour être reproduite ici (Schulz, 1978: 439).

On voit que l'importance du «modello», dans cette théorie, est essentielle, puisqu'elle constitue la trame, la structure du réseau. Sur ce point, J. Schulz est quelque peu vague: le point de vue adopté par l'auteur de la Vue est celui que l'on obtient du haut du campanile de l'église de San Giorgio Maggiore, mais le « modello » aurait subi plusieurs modifications pour faire s'accorder les diverses vues partielles. Il revenait à A. Masciantonio, en 1999 (Masciantonio, 1999: 78), d'avoir mis en lumière la raison pour laquelle la Vue a subi une telle distorsion en faveur de la partie droite. Il observe que si l'on trace une verticale unissant les figures emblématiques, Mercure et Neptune, on constate que cette ligne passe très exactement entre les deux célèbres colonnes qui bornent la Piazzetta au bord de la lagune; elle laisse, par conséquent, immédiatement à sa droite le Palais des Doges et immédiatement à sa gauche les Procuraties. En d'autres termes, l'axe vertical véritable de la Vue coïncide de manière extraordinairement précise, qui ne peut être due au hasard, avec le centre des pouvoirs politiques de la Sérénissime.

Cette vision idéologique, qui allait avoir pour conséquence dans la partie gauche plusieurs problèmes résolus tant bien que mal, avait un immense avantage à droite: elle mettait l'accent sur l'Arsenal, domaine glorieux de la République, montré dans tous ses détails. Cette même vision avait aussi pour conséquence de doubler, aux yeux du spectateur, la longueur de la rive sud de la cité par rapport à celle qui résulterait de l'application d'une perspective strictement scientifique:[2] l'obtention pour le canal de Saint-Marc et le *bacino*[3] d'une énorme superficie, ce qui permettait – ou obligeait – d'y étaler un nombre immense de navires et de bateaux de toutes sortes, enfants de Neptune et de Mercure.

La question de l'identité de l'auteur de la Vue ne nous retiendra guère. Jusqu'à un article de E. Harzen, publié en 1855, la Vue était attribuée à Dürer; Harzen proposa Jacopo de Barbari sur la base de divers indices plus ou moins pertinents.[4] Peu importe, pour notre propos, cette identification de l'auteur: l'auteur de la Vue – appelons-le Jacopo de Barbari – a produit un chef-d'œuvre jamais égalé, chef-d'œuvre ne signifiant pas, on l'a vu, vérité d'évangile.

On a vu quelles sont les causes des « défaillances» de la Vue. A priori, aucune de ces causes n'est de nature à justifier la moindre «défaillance» dans la représentation des navires, bien au contraire: la faveur accordée à la partie droite permettait à l'auteur toutes les libertés dans le choix, le nombre et la disposition de ses navires et excluait donc, en principe, toute licence artistique. Or, dès un premier examen de la «partie nautique» de la Vue, on voit apparaître un phénomène bien étrange: une barque propulsée par douze rameurs (six de chaque bord) est proche, à une distance qu'on peut évaluer à une quinzaine de mètres environ, d'une trirème mue par dix-sept groupes de trois rameurs par bord, soit 102 rameurs au total (Fig. 35.1). Comme la longueur de la galère n'est que très légèrement supérieure au double de la longueur de la barque, l'incompatibilité d'échelle est flagrante, alors que l'espace dévolu à l'ensemble ne manquait pas. Il se peut que le groupe formé par la trirème et les deux navires du même type qui l'accompagnent (Fig. 35.2) ait été inséré à un stade tardif de l'œuvre, qui l'aurait coincé entre des navires marchands déjà dessinés, ce qui expliquerait la taille trop petite des galères.

En d'autres termes, ce phénomène pourrait être expliqué par la technique adoptée par l'auteur dans la théorie de J. Schulz: un «collage» d'éléments disparates selon une perspective incertaine. Toutefois, si cette anomalie nous invite à la prudence quant à l'exactitude des représentations de navires, elle ne peut faire conclure, par hypercritique, à un rejet global des navires de la Fig. 35.2, car, prises individuellement, elles indiquent une excellente connaissance de l'architecture navale. La seule conclusion

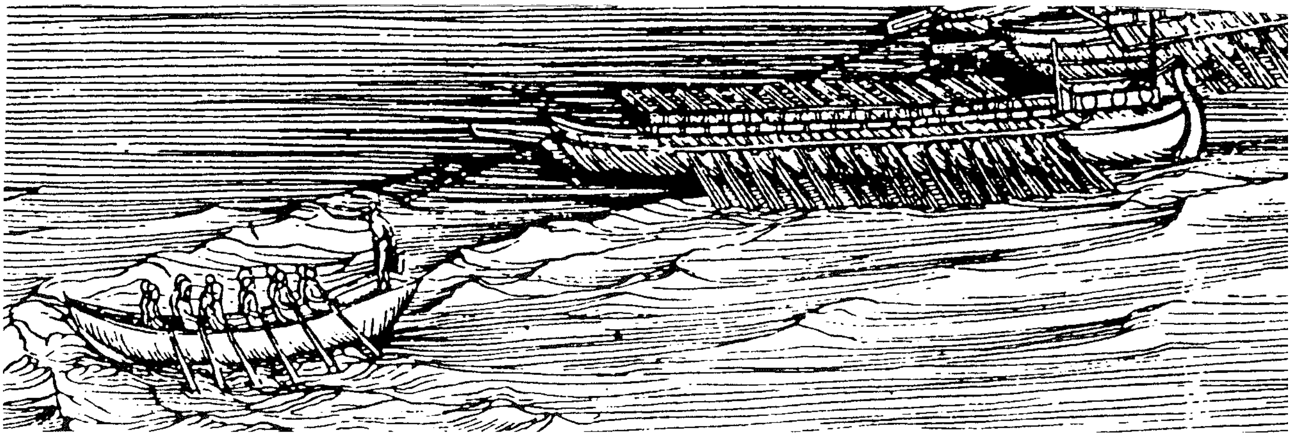


Fig. 35.1. Extrait de la Vue. L'embarcation à douze rameurs n'est pas représentée à la même échelle que la trirème proche.

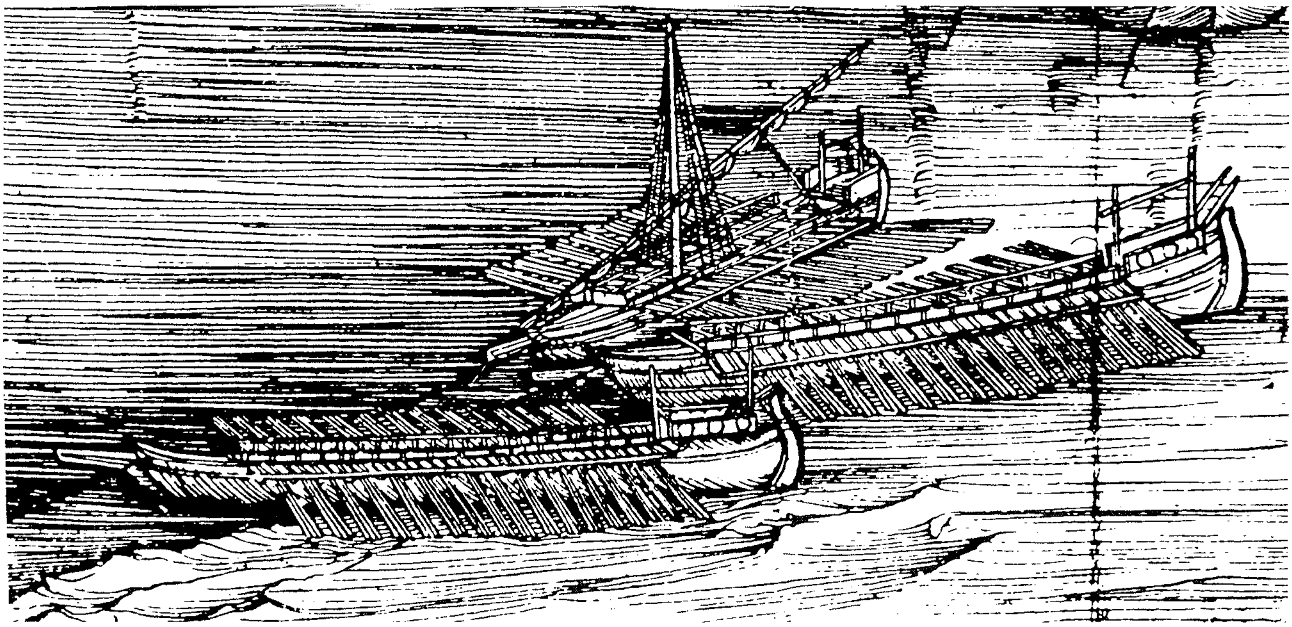


Fig. 35.2. Groupe de trois trirèmes. Extrait de la Vue.

qui, d'emblée, s'impose est que les navires et bateaux de la Vue méritent un examen individuel attentif.

La supplique d'Anton Kolb précise que la réalisation de la Vue prit trois ans. Comme la décision de la Seigneurie date du 30 octobre 1500, le début de l'opération a commencé probablement au cours de la seconde moitié de 1497. Il me paraît raisonnable de penser que les navires ne furent dessinés qu'après le dessin de la ville proprement dite, objet principal de l'œuvre, donc, probablement en 1499 ou au début de 1500, ce qui n'exclut pas que des croquis aient pu être dessinés antérieurement. Cette date est loin d'être indifférente: elle se situe soit au cours, soit à la veille d'une guerre contre les Turcs qui éclate en 1499, alors que la puissance navale de Venise atteint un sommet.[5] Cette puissance est traduite, d'une part, par une augmentation des tonnages tout au long du 15^{e} s., et d'autre part du fait de l'agrandissement continu de l'Arsenal. Les données des archives, sur ce dernier point, sont amplement confirmées par la Vue, ce qui semble démontrer que l'auteur – ou l'un de ses collaborateurs – a pu visiter l'Arsenal jusque dans ses recoins. Plus précisément, il semble que l'Arsenal est représenté tel qu'il devait apparaître en 1499, c'est-à-dire presque vide, à l'exception des navires en construction. En effet, en juillet 1499, pratiquement toute la flotte de guerre est rassemblée au large de Modon (Péloponnèse), sous le commandement d'Antonio Grimani, capitaine général «da mar», pour livrer bataille à la flotte turque qui s'avance pour conquérir Lépante.[6] Au terme des quatre combats navals qui eurent lieu du 12 au 25 août au large de Zonchio, au nord de la baie de Navarin, la flotte turque emporta la victoire, qui entraîna la chute de Lépante. Cette campagne contre les Turcs explique donc très logiquement l'aspect de l'Arsenal dans la Vue.

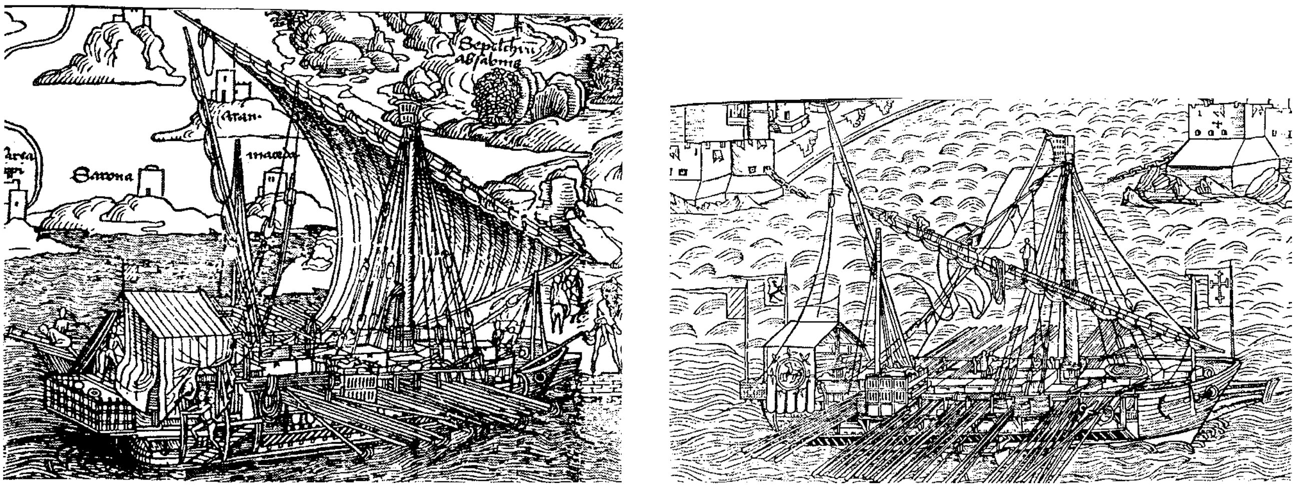
Il est d'autant plus intéressant de tenter de préciser la date des navires de la Vue que nous en possédons une autre, publiée le 11 février 1486 à Mayence dans le livre de Bernhard von Breydenbach, le *Sanctarum peregrinationum in montem Syon ad venerandum Christi sepulchrum in Jerusalem... opusculum,* récit d'un pèlerinage aux Lieux Saints entrepris en 1483 et 1484 par le chanoine von Breydenbach, accompagné de 50 à 150 personnes. Ce récit est illustré de vues des villes traversées, dont Venise, dessinées et gravées sur bois par Erhard Reuwich, d'Utrecht. Le convoi des pèlerins quitta Mayence le 25 avril 1483 et arriva à Venise dans les premiers jours de mai. Le séjour à Venise dura 25 jours, ce qui dut suffire à Reuwich pour réaliser au moins les croquis de ce qui devint une vue de Venise longue de 1,645 m (Cassini, 1982: 35–37) montrant la ville vue du sud sous un angle d'environ 220°. Seule la partie de la ville bordant la lagune est montrée avec un grand luxe de détails; on distingue peu l'intérieur de la ville: on ne voit guère que les campaniles. De l'Arsenal, seule l'entrée est visible. Les erreurs, dans la représentation des édifices, sont très nombreuses, voire grossières; ainsi, les colonnes du Palais des Doges sont au nombre de 11 au lieu de 17 et elles reposent sur des bases qui n'ont jamais existé. Les bateaux et navires qui peuplent la vue de Reuwich sont dessinés avec un mélange de maladresse et d'observations exactes qui les rendent, au point de vue documentaire, difficilement utilisables. Toutefois, certaines de leurs caractéristiques ne peuvent avoir été inventées par le dessinateur, or ce sont précisément celles qui présentent le plus de contradictions avec les images de Jacopo de Barbari, ainsi qu'on le verra, ce qui est d'autant plus curieux que seuls dix-sept ans (1483, date du séjour de Reuwich à Venise, à 1500) séparent les deux vues.

Venise a certainement connu depuis ses origines des navires à voiles (vaisseaux ronds) et des navires à rames (vaisseaux longs). Ces types n'ont pas cessé d'évoluer et, en 1500, les deux types principaux de galères sont la galère *sottile,* c'est-à-dire «mince, effilée», destinée à la guerre, et la *galea grossa,* destinée au commerce.[7] De cette dernière, nous possédons des images dues à Reuwich, dans le récit du pèlerinage de Breydenbach (Figs. 35.3 et 35.4). Aucun navire, dans la Vue, n'y ressemble, même de loin, ce qui peut s'expliquer par la mobilisation des galères de commerce en 1499 lors de la guerre contre les Turcs. On peut conclure que les galères présentes dans la Vue sont toutes purement militaires, du moins à première vue.[8]

La galère *sottile* était une trirème de 25 à 30 rangs de bancs et à trois hommes par banc, chacun d'eux actionnant une rame. Elle n'avait qu'un seul mât, même au 16^{e} s., alors que les galères marchandes en portaient deux, d'après le témoignage de Reuwich, et parfois trois, d'après les sources écrites.

Le groupe de galères le plus prometteur au point de vue documentaire est celui que forment trois trirèmes très rapprochées au centre du canal de Saint-Marc (Fig. 35.2):[9] ce sont les seules galères de la Vue qui montrent leurs rames. On peut compter le nombre de bancs à bâbord sur la galère la plus rapprochée du spectateur, ainsi que sur sa voisine immédiate: dix-sept bancs dans les deux cas, chiffre inconciliable avec celui d'une galère *sottile.* On ne peut perdre de vue qu'il existait des bâtiments à rames plus petites que cette dernière: les *fuste, galeotte, bregantini* et *fregatte.*

La *fusta* pouvait être armée par deux à trois hommes par banc et le nombre de bancs était inférieur à 25; Jal en cite une à dix-huit bancs (Jal, 1848: 276). Le dessin montre



Figs. 35.3 et 35.4. Galères marchandes de Venise, en 1483. Xylographie de Reuwich, publiée en 1486.

bien que les bancs étaient occupés par trois rameurs (puisque l'on distingue des groupes de trois rames: ils étaient sans doute dissimulés par la pavesade qui les protégeait. On remarque, à la poupe, deux perches verticales dont les sommets sont réunis par une perche horizontale, qui avait pour rôle de supporter une toile, le tendelet.

Sur la galère centrale de la Fig. 35.2, le gouvernail est dominé par deux perches obliques, qu'on retrouve sur une galère vénitienne de Reuwich (Fig. 35.5). Je n'ai pu découvrir la fonction précise de ces perches, représentées réunies sur la Fig. 35.5.

Un couloir central, la coursie, va de l'avant à l'arrière; elle est entourée d'une rambarde de chaque bord. La Vue montre des galères identiques, mais dépourvues de rames: Fig. 35.6 et 35.7.

Dans l'*Arsenale Nuovo* figurent trois galères (Fig. 35.8). Sont-elles toutes du même type? Comme celle de droite est abattue en carène, on n'en distingue guère que les baccalats qui soutiennent l'apostis, mais on lui voit deux mâts, caractéristique partagée par les deux galères de gauche. Bien que les traits horizontaux soient passablement enchevêtrés sur ces dernières, il ne semble pas qu'on y retrouve les pavesades et les rambardes des galères des Fig. 35.2, 35.6, 35.7 et 35.8.

À quel genre de galères appartiennent ces trois bâtiments? La longueur de l'*Arsenale Nuovo* était d'environ 300 m, d'après l'excellent plan de l'Arsenal en 1475 donné par Bellavitis, 1983: 60, pl. IV. Si l'on en juge d'après la Fig. 35.9, la longueur de la galère de droite occupe les 6/21es de la longueur du bassin, ce qui revient à attribuer à cette galère la longueur absurde de 86 m: elle est donc certainement représentée hors d'échelle, comme si l'auteur avait voulu «remplir» à tout prix une importante partie de l'Arsenal qui, en réalité, était pratiquement vide en 1499.

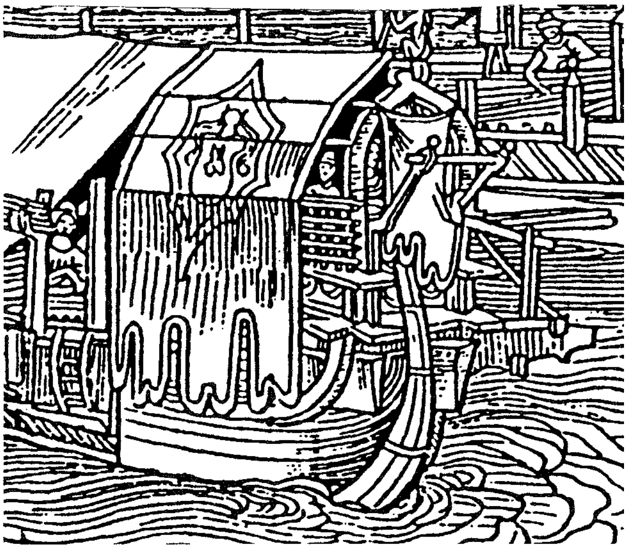
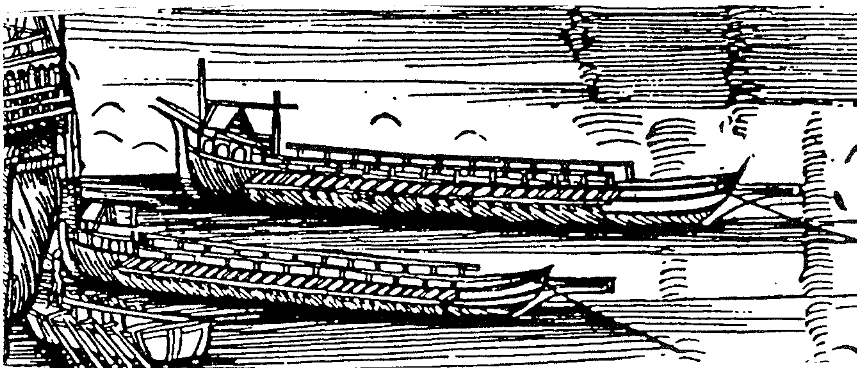
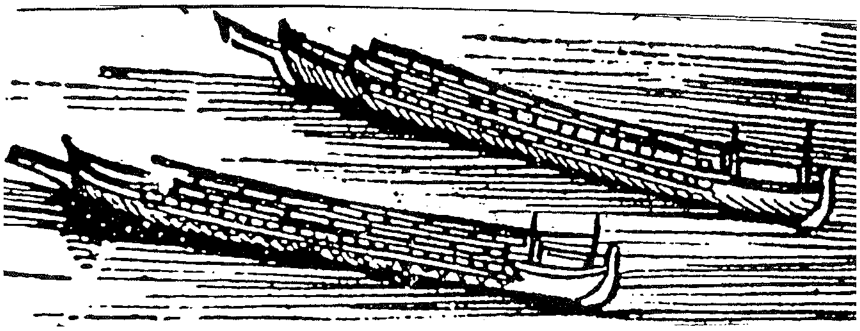


*Fig. 35.5. Poupe d'une galère (*galea sottile*), vue à Venise en 1483. Xylographie de E. Reuwich, publiée en 1486.*





Figs. 35.6 et 35.7. Galères du même type que celles de la Fig. 35.2, mais dépourvues de rames. Extraits de la Vue.

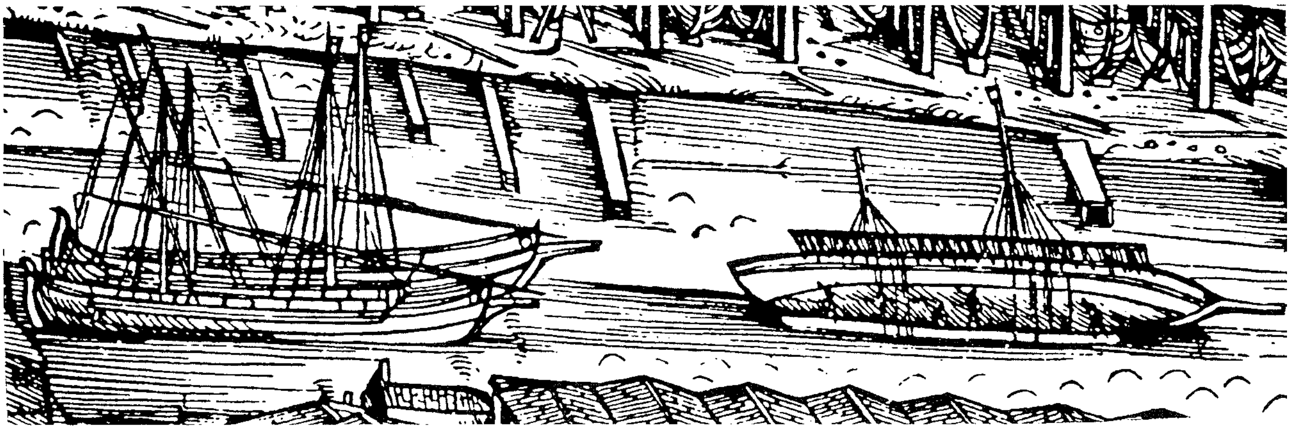


*Fig. 35.8. Vue partielle de l'*Arsenale Nuovo. *Extrait de la Vue.*

On observera que les quatre ouvriers qui carènent la coque sont, eux aussi, probablement figurés hors d'échelle par rapport à l'étendue du bassin; mais on peut se demander s'ils ne sont pas représentés à la même échelle que le navire qui est l'objet de leur labeur.

Cette question paraît d'autant plus légitime que le dessin, ici, est très soigné; ainsi, les redresses, forts cordages servant à relever le navire abattu en carène, sont figurés méticuleusement. Si l'hypothèse d'une identité d'échelle entre le navire et les ouvriers était fondée et si l'on attribue au corps du troisième ouvrier à partir de la gauche une hauteur de 1,70 m, la longueur de la galère, éperon compris, serait d'environ 23 m, ce qui est parfaitement raisonnable: Jal nous dit que «les fustes de douze, treize, quatorze et quinze bancs étaient de celles que leurs rapports apparents pouvaient faire prendre pour des brigantins» (Jal, 1848: 276). Les galères de l'*Arsenale Nuovo* pourraient donc bien être de petites fustes. Pourquoi ces galères d'un rang très inférieur avaient-elles deux mâts, alors que les plus grandes (Fig. 35.2) n'en ont qu'un? Peut-être pour compenser la diminution de la force motrice fournie par les rames?[10]

Revenons aux grandes fustes de la Fig. 35.2 et à leurs semblables. Ces navires de guerre indiscutables sont dépourvus de l'armement principal de la galère: la grosse pièce de canon placée à l'avant dans l'axe du navire et tirant par-dessus l'éperon, le coursier — ce qui nécessite évidemment un avant plat. Un tel canon figure, très correctement, sur une galère de Reuwich, que celui-ci a vue à Venise en 1483 (Fig. 35.9). On voit ce même canon à l'avant des galères turques à la bataille de Zonchio (1499) (Fig. 35.10). Par ailleurs, la trirème peinte par Carpaccio dans le cycle de Sainte Ursule en 1495 (Fig. 35.11), de même qu'une galère figurant sur une carte de Grazioso Benincasa de 1482 (Fig. 35.12), sont pourvues d'arganeaux (équivalents des bossoirs dans la langue des galères) et non d'écubiers. Or toutes les galères de la Vue sont dotées d'écubiers, et non d'arganeaux, ce qui est logique, les arganeaux exigeant, de même que le coursier, un avant plat, appelé, dans la langue des galères, tambouret, tambourin ou tabourin.

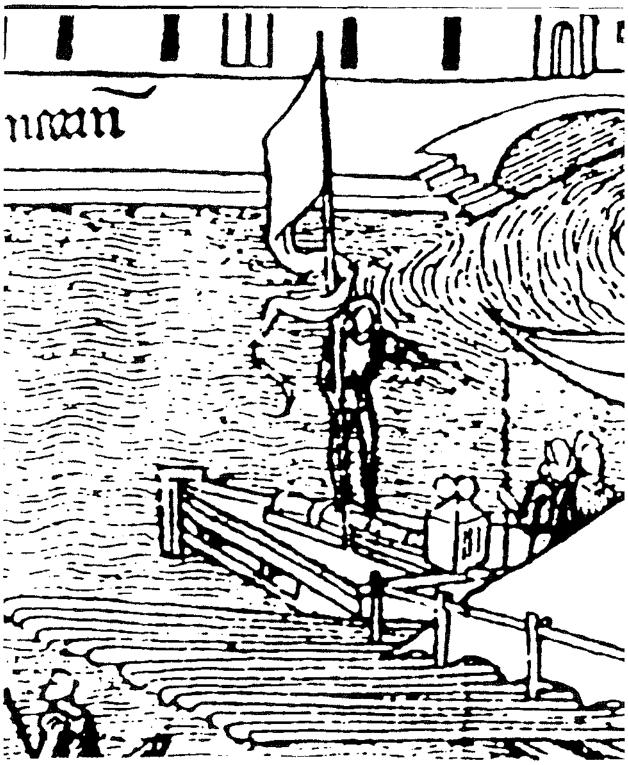


*Fig. 35.9. Proue d'une galère (*galea sottile*), vue à Venise en 1483. Xylographie de E. Reuwich, publiée en 1486. On distingue clairement le canon (coursier).*

Les écubiers sont, à leur tour, logiques sur un avant «en cuillère», qui est typique de toutes les galères de la Fig. 35.2, mais aussi des galères marchandes de Reuwich (Figs. 35.3 et 35.4), qui sont aussi pourvues d'écubiers.

Les galères de la Vue seraient-elles de fantaisie? Comme il ne s'agit pas des galères «classiques» à 25 ou 30 bancs, toutes mobilisées hors de Venise en 1499, mais

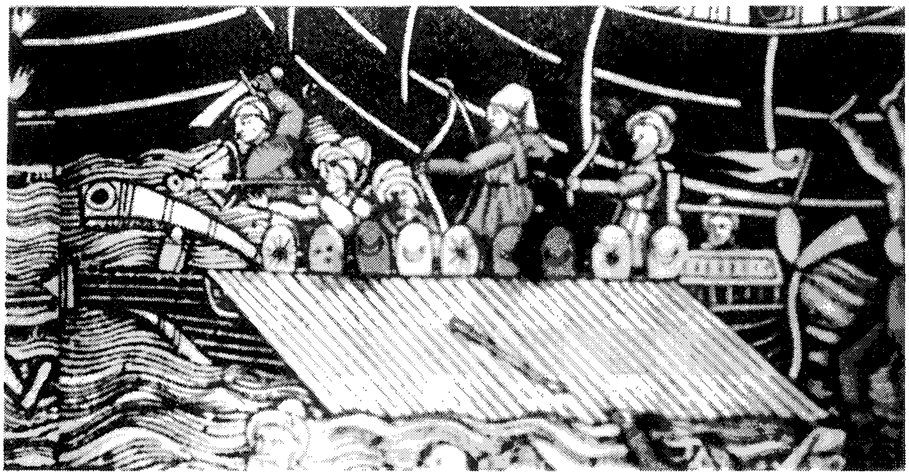


Fig. 35.10. Galère turque à la bataille de Zonchio (1499). Détail d'une xylographie contemporaine.

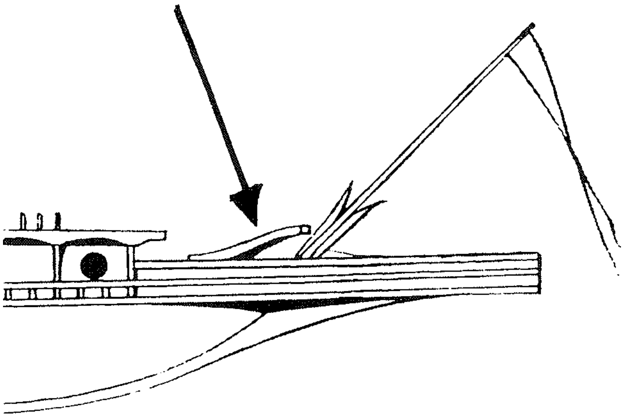


Fig. 35.11. Reconstitution de l'avant d'une galère vénitienne peinte par Carpaccio en 1495, par B. Landström, 1963: 129, Fig. 319: l'arganeau (flèche).

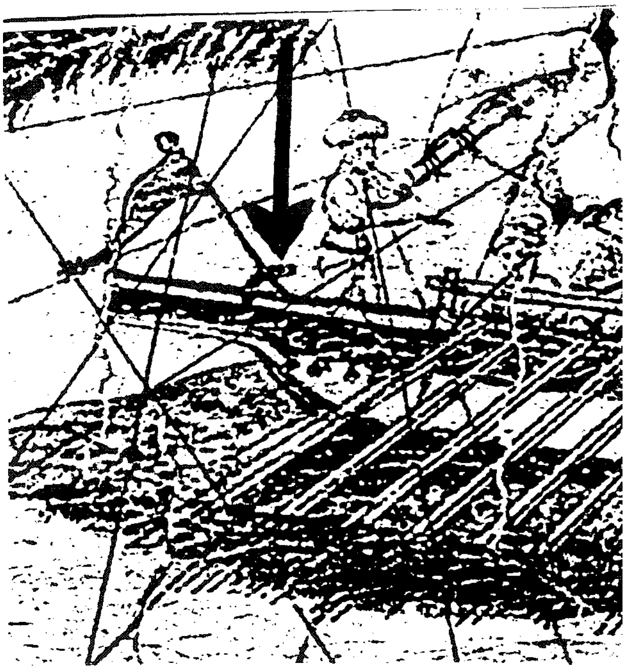


Fig. 35.12. Avant d'une galère décorant une carte de Grazioso Benincasa (1482), Università di Bologna. Près de la base de la hampe du pavillon triangulaire: l'arganeau (flèche).

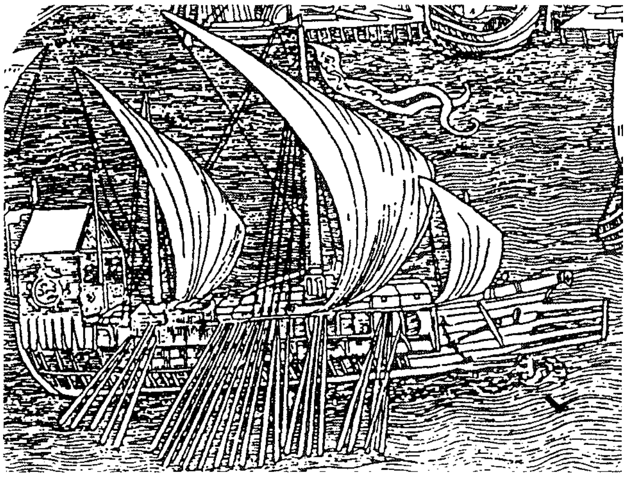


Fig. 35.13. Galère marchande vénitienne à Anvers, à étrave « en cuillère » et portant un canon. Xylographie datant de 1515, au Musée Plantin, à Anvers.

de fustes, jugées suffisantes pour la défense de la ville elle-même, il n'y a pas lieu de mettre en doute l'exactitude des galères de la Vue.

Il faut observer que l'absence de coursier était loin de rendre la fuste inoffensive: les arbalétriers vénitiens étaient redoutables. Enfin, il est possible qu'en cas de nécessité absolue, un canon pouvait, par des moyens de fortune, être placé sur un avant «en cuillère»: c'est ce dont témoigne une représentation de galère marchande vénitienne à Anvers en 1515 (Fig. 35.13).[11,12]

Notes

[1] Les Fig. 35.7 et 35.8 de l'article de Schulz (1978: 438) illustrent clairement cette distorsion.

[2] Si, comme tout l'indique, le point de vue adopté se situe au sommet du campanile de San Giorgio Maggiore ou à la verticale de celui-ci.

[3] Le canal de Saint-Marc est la partie de la lagune immédiatement au sud de Venise, grossièrement entre la Douane de mer et Sant'Elena; le *bacino*, ou bassin, de Saint-Marc est l'étendue d'eau qui s'étend devant la Piazzetta et le Palais des Doges.

[4] L'attribution à Jacopo de Barbari a été fortifiée par l'argumentation de Mazzariol et Pignatti, 1962. Cette attribution n'a plus jamais été sérieusement contestée (voir cependant: Schulz, 1978: 426, n. 3), mais elle ne repose toujours que sur des indices.

[5] Sur les opérations navales de cette guerre: Lane, 1983.

[6] Pour les effectifs vénitiens engagés: Lane, 1965: 253–258 («La liste des navires de 1499») et Lane, 1983: 255–256.

[7] Sur cette distinction, on peut encore utilement consulter Lane, 1965: 1–31.

[8] Les bâtiments militaires étaient exceptionnellement employés pour transporter d'urgence des produits de grande valeur, p. ex. une cargaison d'or à Tunis (Lane, 1965: 13).

[9] On pourrait croire que ces galères sont dépourvues de leur câble d'ancre: il est cependant indiqué sur la galère la plus proche du spectateur et sa voisine, mais le câble se perd quelque peu dans l'encrage.

[10] Certes, J. Jouve, en 1679, montre, portant deux voiles latines, des brigantins à 14 rames par bord (pl. 5 et 6), mais, à cette époque, les galères portent également deux mâts.

[11] Cette estampe, dont il n'existe qu'un seul exemplaire, est exposée au Musée Plantin, à Anvers; l'auteur, anonyme, s'est manifestement inspiré des galères de Reuwich. Sur ce document: Buyssens, 1952.

[12] J'ai publié, en 2000, à compte d'auteur (édition à cent exemplaires), une monographie «Les navires et bateaux de la Vue de Venise de Jacopo de Barbari», qui, comme son titre l'indique, examine l'ensemble des navires et de la batellerie de la Vue.

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36. *Kadırga*
A Technical Analysis of the Sultan's Galley

Erkut Arcak

Introduction

The Sultan's galley, *Kadırga*, on display in the Istanbul Naval Museum, is the only authentic historic galley in existence (Fig. 36.1). It is one of the oldest historical ships in the world, perhaps the oldest of all well-preserved ships whose existence is not based on archaeological excavation. This small galley was used for ceremonial purposes and short excursions by the Ottoman sultans on the Bosphorus and Sea of Marmara and, fortunately, has been preserved for centuries for us to see now.

Like a mysterious shipwreck, this vessel poses various complex problems. The major difficulty is the unknown origin of the vessel. Owing to the lack of documentation of when *Kadırga* was built or to whom it originally belonged, there has been no more than mere speculation. Based on an inscription in the stern cabin naming a certain Mehmed, there is a common belief that *Kadırga* belonged to Sultan Mehmed IV (1648–1687) and the galley is still displayed as belonging to this Sultan (Tezel. Galikoğlu, 1983:49). According to some views, the vessel may have belonged to Sultan Mehmed II (1444–1446 and 1451–1481), the conqueror of Constantinople. On the other hand, Lucien Basch, asserts that *Kadırga* may have been used by the last Byzantine Emperor, Constantine XI Dragazes (1449–1453), from whom it was obtained by Mehmed II after the conquest of Constantinople (Basch, 1979: 49).

Considering the importance of this ship and taking into consideration these speculations, Cemal Pulak and the author initiated the project of the Sultan's Galley in the

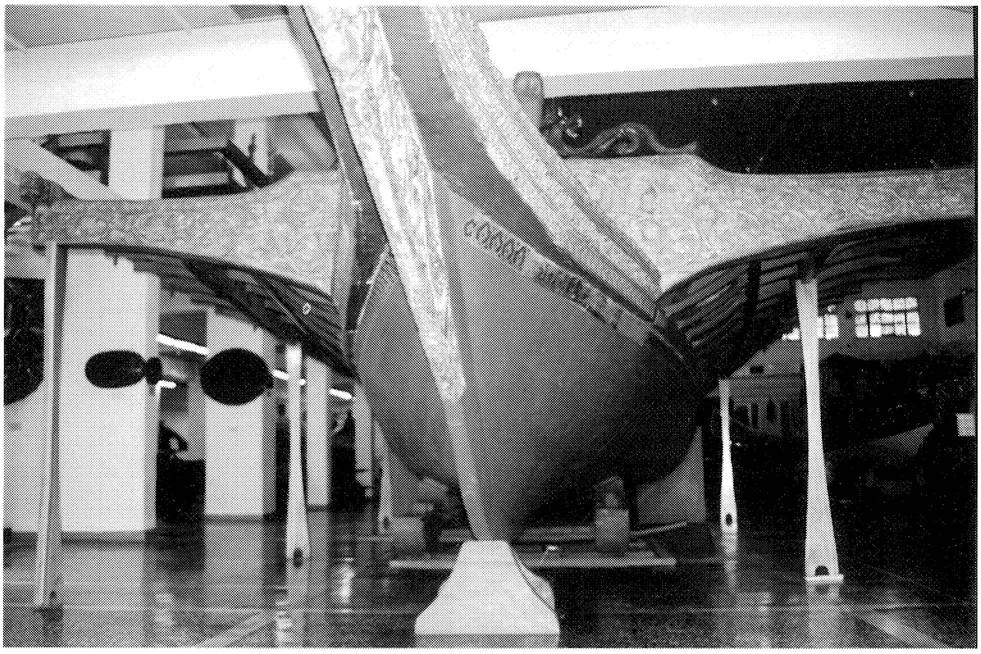

Fig. 36.1. Kadırga *on display at the Istanbul Naval Museum (photo: Erkut Arcak).*

summer of 1999 in order to clarify *Kadırga*'s perplexing story as well as to investigate the structural features of this unique vessel. The goal of this research is to examine and determine the original portion of *Kadırga* and to analyze the details of the vessel's construction. The researchers aimed to generate accurate and comprehensive line drawings, construction plans, and detailed documentation of the various renovations and restorations that the vessel had been subjected to during its long lifetime.

An accurate documentation of this ship is crucial: it would be impossible to elucidate the exact story of *Kadırga* without documenting the ship fully, since no entirely accurate plan for the vessel currently exists. As Basch has previously noted, several inaccurate drawings for the ship are available, but these differ from each other as well as from the present version of the ship (Basch, 1979: 43; Basch, 1998: 229). The French naval architect Le Bas produced a plan of the vessel in 1861 that was published by Admiral Pâris (Fig. 36.2; Pâris, 1908: pl. 312). It shows *Kadırga* with a slightly rockered keel, whereas a plan published by Ata Nutku almost fifty years later shows the galley with its present straight keel (Fig. 36.3; Nutku, 1957: 21). Although these perplexing representations of the ship spawn many questions, they are invaluable sources of information for understanding the ship's origin and they allow us to trace the various restorations and renovations that the ship underwent during its long lifetime. Part of the answer to the unknown origin of the ship lies in these contradictory representations.

For example, our preliminary investigations suggest that *Kadırga* was originally built with a rockered keel as shown in Le Bas' representation of 1861 (Pâris, 1908: pl.312). This was later replaced with a straight keel during a major restoration and renovation process. It is known from historical documents that the straight keel was in use by the beginning of the 17th century and that earlier galleys were constructed with slightly rockered keels. This important evidence indicates that *Kadırga* could have been built before the 17th century, with an even earlier construction date well within reason.

Undoubtedly, it is a difficult task to provide a complete picture of this ship within the limits of this paper. For this reason, it is only intended here to discuss our preliminary results along with a brief description of the ship's constructional features.

Description of the Hull

The overall length of *Kadırga* is 39.57 m (from beak to the after end of the stern gallery) and its maximum breadth is 5.72 m (between the outer sides of the outrigger). On the prow, there is a 5.45 m-long beak projecting beyond the stem to which it is connected with a z-scarf. The sides of the beak are decorated with various carved motifs, including *basilisk* (a dragon-like beast) figures. The most fascinating part of the ship is its kiosk or stern cabin, which is adorned with semi-precious stones, mother-of-

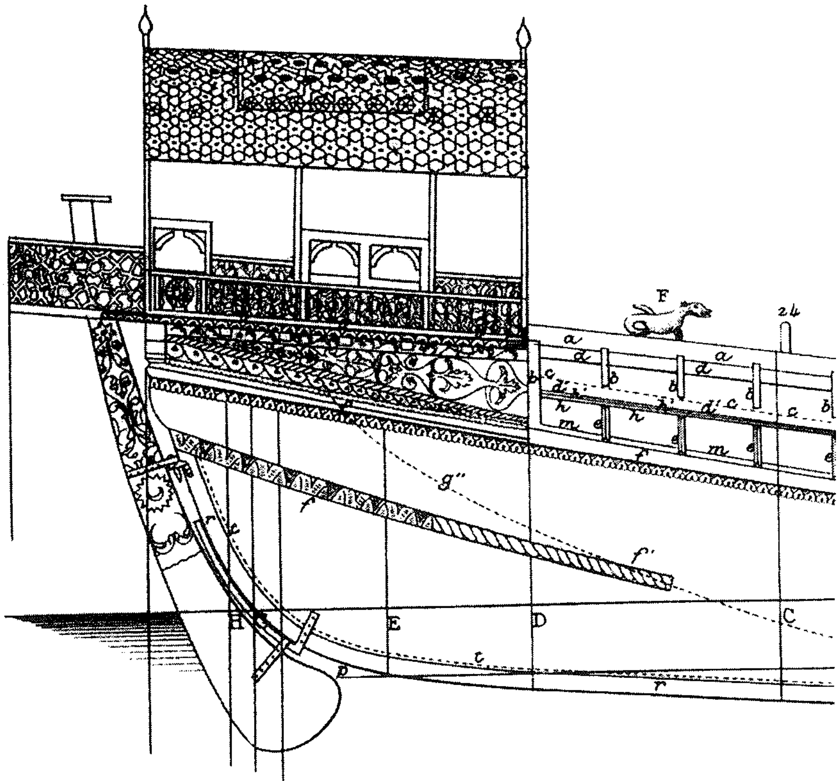

Fig. 36.2. Kadırga *represented with a rockered keel by Le Bas in 1861 (after E. F. Pâris, 1908: pl.312).*

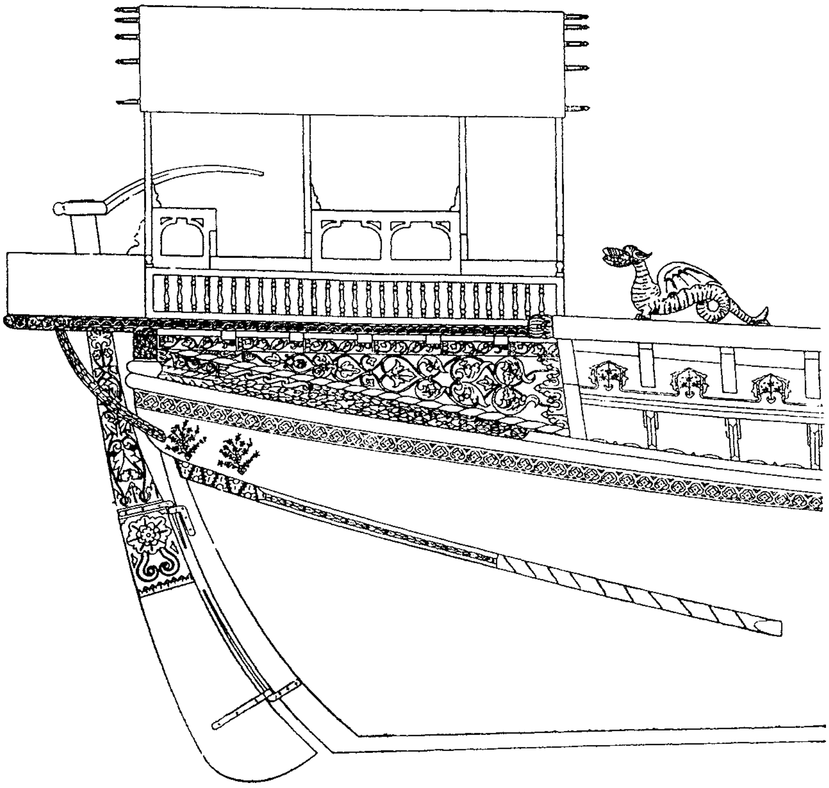

Fig. 36.3. The representation of Kadýrga *on Nutku's plan (after A. Nutku, 1957: 21).*

pearl, tortoise shell, ivory and silver. A poem inlaid with mother-of-pearl and tortoise shell on the interior of the cabin provides the clue that the galley's owner was Sultan Mehmed.

The vessel's outrigger box is most interesting as it is the only surviving historic example of this construction element (Fig. 36.4). It is 28.65 m long and 5.72 m wide. This rectangular superstructure was made using two transverse beams (*zovi)* placed at either end of the galley and two long timbers (*apostis*) placed on each side where the thole pins were located.

The outrigger is supported by forty-eight L-shaped knees (*baccalari*) nailed to the main deck, bulwark and the waterway. Between the *apostis* and bulwark (*boutasse*) of the ship are placed a pair of planks called *banda,* which provide additional longitudinal stiffness and flexibility to the outrigger. The *banda* planks are notched along their edges to receive each *baccalari* and run the entire length of the outrigger parallel to the bulwark. The forty-eight *baccalari* are also supported by an equal number of smaller support timbers (*colla de late*), which are placed over the main wale and attached with a long stringer under the *baccalari* (Fig. 36.5).

The *boutasse* was placed over the waterway, running from the forward end of the outrigger to its after end. In order to provide water drainage from the cambered main deck (*coverta*), two adjacent crescent-shaped cuts were made on its lower edge. Additionally, a rectangular notch between the crescent-shaped cuts probably accommodated the *colla de late*, which correspond in spacing to that of the notches on the *boutasse.* However, the *boutasse* now appears to have been shifted and the forty-eight *colla de late* no longer line up with the notches that were cut to receive them. It is not clear whether this is due to hasty craftsmanship by the restorers or some other factor. That they were represented in Nutku's drawing in their correct configuration suggests that all the timbers are the original structural pieces (Nutku, 1957: 21).

The gangway *(corsia)* is located on the longitudinal centerline of the main deck and runs the entire length of the main deck from one *zovi* to the other. It is one of the most important structural elements of the ship, providing longitudinal reinforcement to the entire hull. It lies 74 cm above the main deck and has an average width of 36 cm. Although it is not covered, except at the extremities, there was probably a removable companionway that provided easy access from stern to prow.

The rowers' benches are attached to the central gangway by means of dovetail scarves on either side of the gangway. There are twenty-three benches on either side, with the twenty-fourth bench removed at some unknown date. The port bench socket of the first bank on the forwardmost end of the gangway is still visible, while that on the starboard is concealed by a compartment that was added at a later date.

The 30.04 m long straight keel is sided 10 cm and

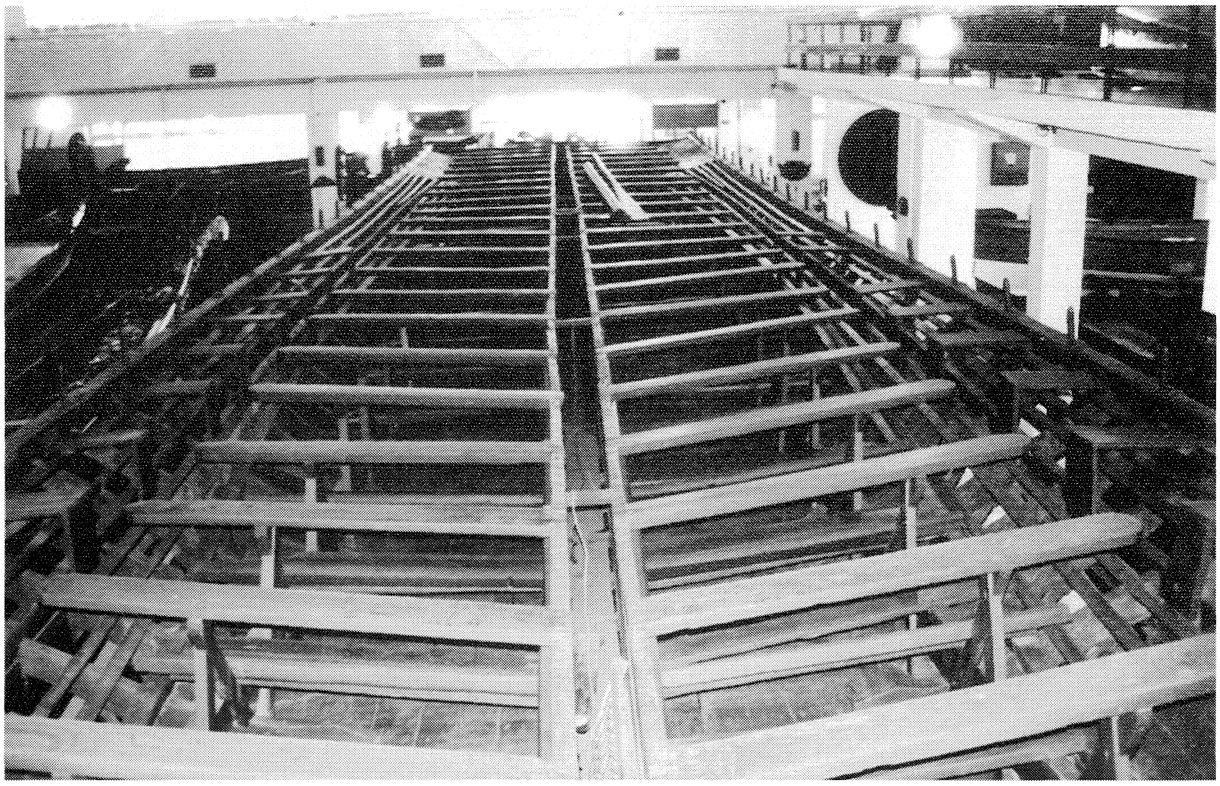

Fig. 36.4. The outrigger of Kadırga *(photo: Erkut Arcak).*

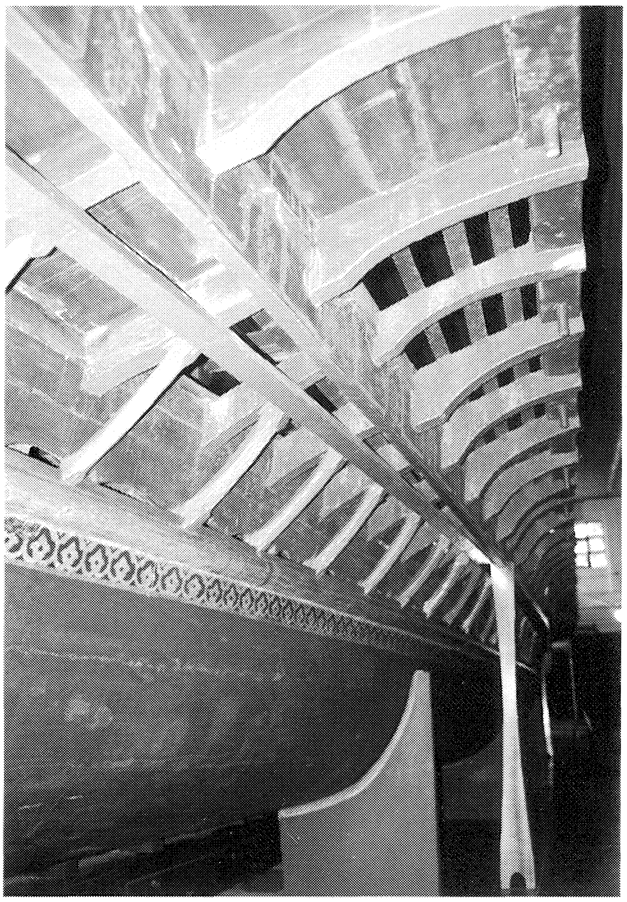

Fig. 36.5. Outrigger construction from below (photo: Erkut Arcak).

molded 15 cm. It is constructed of four pieces joined with diagonal horizontal scarfs. The keel is joined to the stem with a hook scarf whereas it is joined to the sternpost with a mortised lapped-scarf and secured with clenched iron nails and iron bolts. Rabbets are cut into the upper edges of the keel, and on the stem and sternpost to receive the termination of planking ends.

The curved sternpost is made up of two pieces attached to each other by means of a z-scarf secured with four iron bolts. It is set at an angle to the straight keel and joined to it with a mortised lapped-scarf and iron bolts. Similarly, the stem is made up of two pieces (joined with a z-scarf) and connected to the keel with a hook scarf, but in this case secured with a wedge and two bolts and an iron spike. An apron, molded 30 cm at its widest part, was placed at the bow between frames 1 and 4, bolted to the stem, and also attached to the keelson with a flat scarf and two iron bolts over the floors.

The frames of *Kadırga* were made up of single futtocks and floors running across the top of the keel to well outboard, following the classical Mediterranean tradition. There are 127 futtocks in place (Fig. 36.6). However, some of the floor timbers were removed and others left unattached to their futtocks during the heavy restoration process.

For this reason, there are only 98 floor timbers left in place. Despite this irregularity, original floor and futtock junctions are still preserved in some parts of the ship. In these areas the floors and futtocks overlap each other with a knuckle joint and were secured with three double-clenched square iron nails, with one being driven from the

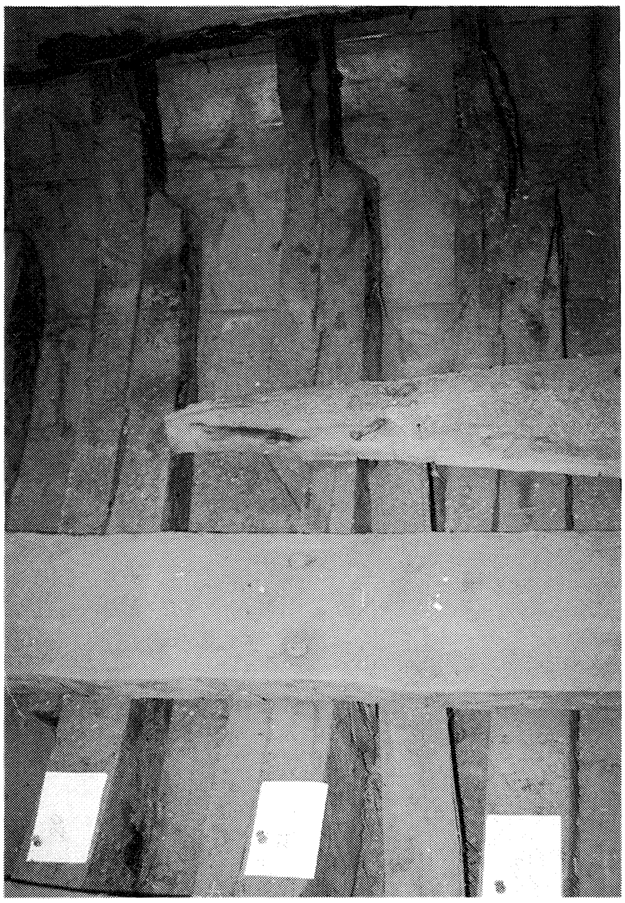

Fig. 36.6. Frames of Kadırga *(photo: Erkut Arcak).*

opposite direction. The futtocks are molded 8 cm and sided 8 cm on average, whereas floor timbers are sided 8 cm and molded 10 cm; all frame timbers were cut beveled at their ends. The original room and space between each frame is 34 cm on average. The replaced frames were neither beveled nor fastened with a knuckle joint, but merely overlap each other.

There is no evidence for a master frame as found on other examples of hulls belonging to the early modern period. It was not difficult, however, to locate the midship frame (frame 63) since the futtocks are placed before the floor timbers forward of frame 63, and abaft the floor timbers after frame 63 (Fig. 36.7).

The framing of the stern is made up of seven Y-shaped frames (Fig. 36.8). There are no short floors in this area, instead half floors are connected to each other at their lower ends and secured by means of chocks.

A pair of fashion pieces, corresponding to frame 127, is bolted to the sternpost above the inner sternpost supporting the aftermost ends of a pair of melon-ended log planks.

The planks of *Kadırga* are 35 mm thick on average. However, the sheer strake is thicker (50 mm) than the other planks and notched on its inner surface to permit a better join with the futtocks. The planks are butt-joined to form the strakes and are attached to the frames with square nails driven from the exterior of the hull. At midships there are eight broad strakes on either side of the hull with average widths of 25 cm. The flat bottom is about 3.92 m wide amidships and was designed with a slight

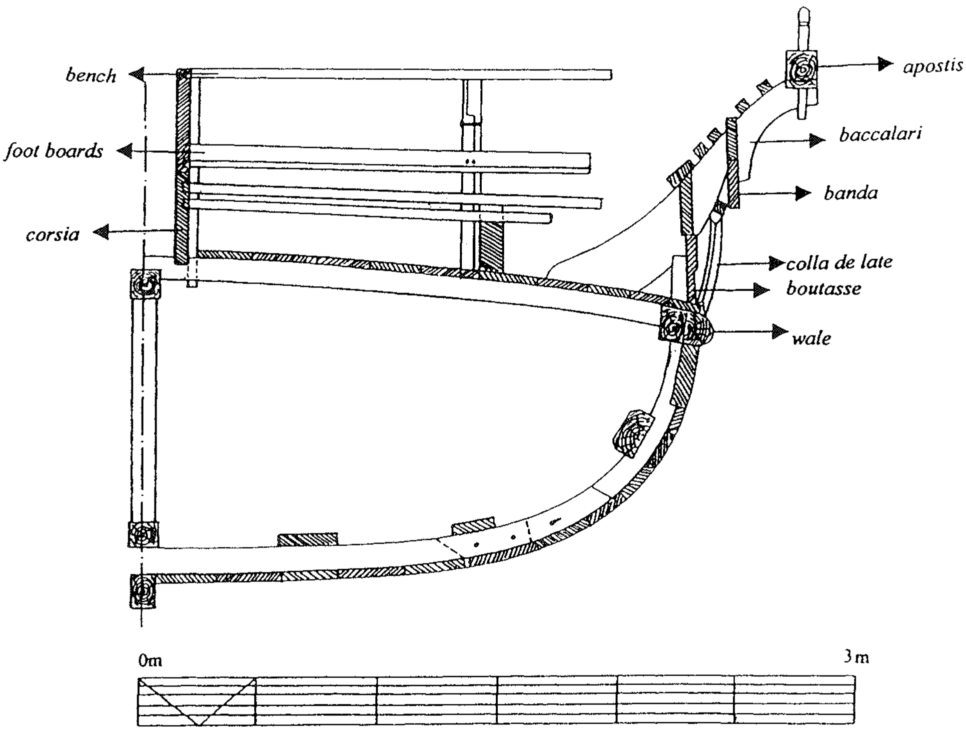

Fig. 36.7. Midship cross-section (drawing: Erkut Arcak).

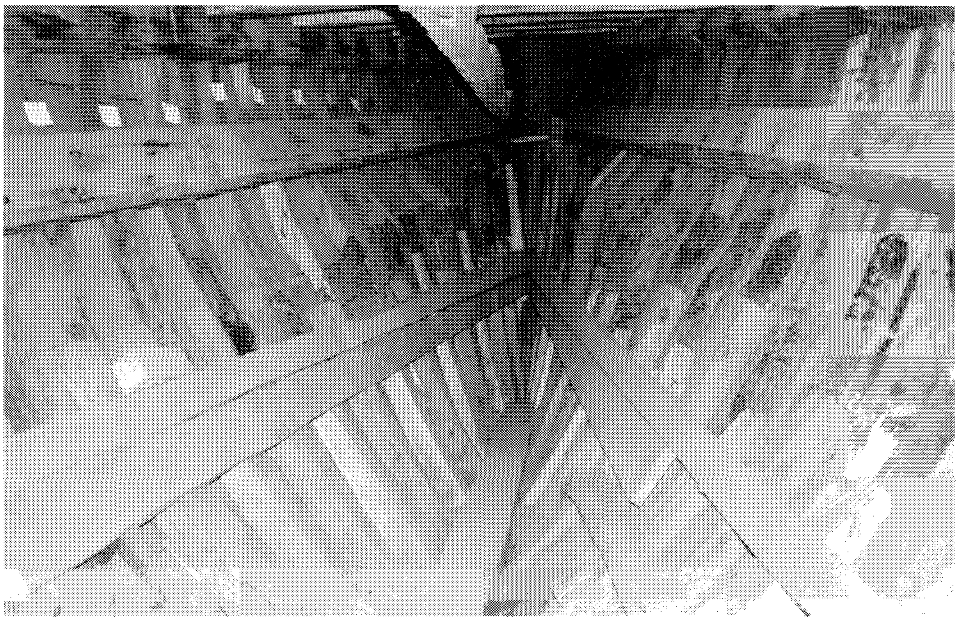

Fig. 36.8. The view of the stern from inside (photo: Erkut Arcak).

deadrise and soft round bilges; the sides flare only slightly to give them a vertical appearance. All the strakes narrow toward the extremities to permit better joining with the end posts. The melon-ended log planks that form the stern are among the most distinctive features of the galley, imparting an elegant appearance to the rounded stern. Each plank was carved from a solid log, 55 cm wide and 9 cm thick, and attached to the sternpost with a sharp, rounded turn at the aftermost end.

The main wale consists of four pieces on either side, running directly above the sheer strake from foremost point of the beak to the sternpost. It is sided 10 cm and molded 13 cm, and its protruding sides are rounded in section. Apparently, the purpose of the wale is not only to provide longitudinal strength to the hull but also to support the outrigger with the forty-eight *colla de late* that are joined on its upper surface. Above the main wale, a waterway of rectangular section was fitted in place; the waterway is notched in order to accomodate the forty-eight *colla de late* on either side of the hull.

A short stern wale, called the *massane,* is placed over the crotches of Y-shaped stern frames and join them to the sternpost. It begins at the sternpost, to which it is nailed, and extends forward to support all of the crotched frames. The forward end of the *massane* is located at frame 113 on the starboard and frame 112 on the port side, at locations where the frames cease being crotches.

There are fifty-four deck beams, rectangular in section. The room and space between each one is 70 cm on average, and their ends are locked into the notched shelf clamp on either side of the hull. Below the gangway, a longitudinal counter-timber runs from stem to stern under the deck beams and is supported by stanchions.

A shelf clamp, placed below the deck beams, also runs from stern to stem. It consists of three pieces fastened to each other with long z-scarfs. The exterior face of the clamp is notched 30 mm deep to accommodate the frames and the clamp is nailed to every futtock with two iron spikes. Its upper surface is also notched to meet with the deck beams and support them from below the deck level.

There are seven stanchions mounted on the keelson to support the deck. The upper ends of the stanchions are locked into the long counter-timber, which is notched to receive each stanchion. Four additional stanchions are placed over the floorhead stringer on either side to provide additional support for the main deck. These extra timbers were most likely placed during the restoration of the ship to support the main deck at these points.

Preliminary Analysis of Kadırga

The partially altered hull of *Kadırga* presents one of the biggest difficulties in interpreting its construction. Due to structural failure of the hull, the vessel was continuously repaired and renovated, and the entire section of the hull below the waterline was completely replaced at some point. One of the most perplexing constructional feature is the sternpost assembly that was also altered during the heavy restorations. In its present condition, the curved sternpost is set at an angle to the straight keel. This is one reason why some scholars think that *Kadırga* is a 17th-century galley rather than one built in the 16th century or perhaps earlier (Lehmann, 1990: 254).

On the other hand, the plan of *Kadırga* made by Le Bas in 1861 shows the vessel with a slightly rockered keel and curved keel-sternpost junction, which is different than its present condition (Paris, 1908: pl. 312). This difference is striking. Unfortunately, one cannot assume that Le Bas' drawing shows *Kadirga* as it really was in 1861. It remains unclear whether this was a biased representation or *Kadırga*'s is present form resulted from a restoration that occurred sometime after 1861. Although we have no known account of the keel's replacement, it seems possible that during this major modification the original rockered keel was replaced with the present straight one.

To better explore this intriguing question it was necessary to investigate the inner construction of the ship, especially its stern assemblage. It seems that framing of the stern, the inner sternpost, and the sternpost junction was modified, and that the present keel is indeed a replacement of the original.

The strongest evidence of this comes from the inner sternpost, which has been sawn short at both the sternpost and keel ends. In fact, the keel end has been cut so short that the inner sternpost no longer spans the keel-sternpost junction. Moreover, the inner sternpost does not rest or sit on the keel, nor is it fastened to it in any obvious way – something rarely seen in the long tradition of shipbuilding (Fig. 36.9). There is in fact, nothing unusual about this ship, if one considers that the galley was not intended to be used again in the service of the sultans after its restoration.

Apart from this feature, a new timber was placed on top of the keel. This "inner keel", sided 10 cm and molded 8 cm, begins at floor 126 and ends at floor 112. It sits flush with the straight keel, and the replacement floor timbers are fastened to its top surface. Furthermore, the upper half of the sternpost appears to be older than its lower half, as revealed by the irregularity of its aft surface. Most probably, the melon-ended log planks, which are attached to the sternpost at this location, made its complete removal difficult. For this reason it is likely that the upper half of the sternpost above the z-scarf was retained and only its lower half was changed along with the keel.

By superimposing the Le Bas drawing with our own version, we found the curvature of the inner sternpost in both representations to match perfectly (Fig. 36.10).

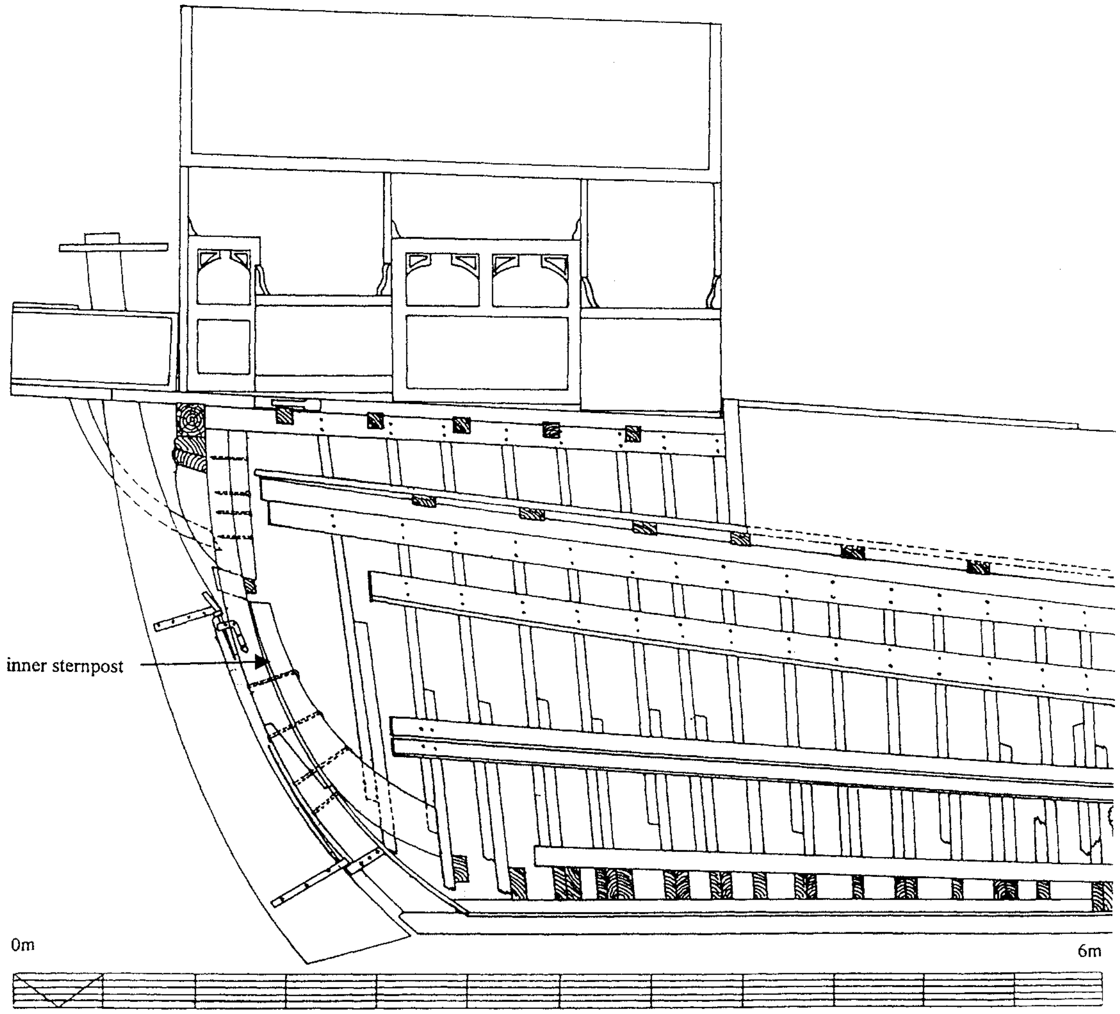

Fig. 36.9. Construction plan of the stern assemblage (drawing: Erkut Arcak).

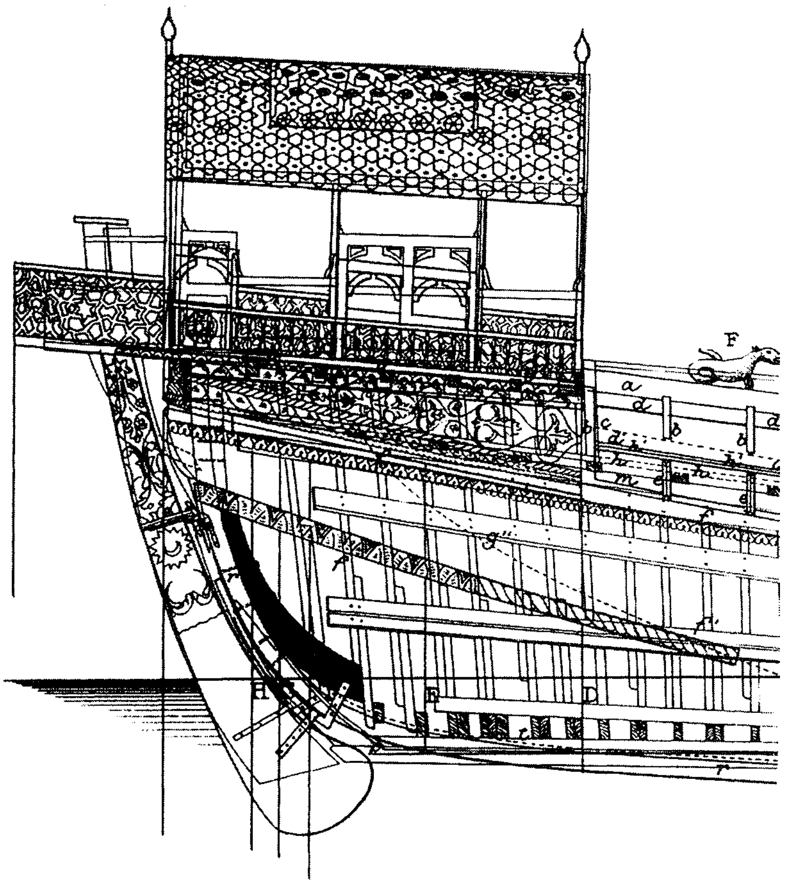

Fig. 36.10. The curvature of inner sternpost in the ships' present condition and the curvature of the sternpost on the Le Bas plan from 1861.

Thus, it is highly likely that *Kadırga* was originally built with a rockered keel that was later replaced with a straight one in keeping with the design and construction requirements of later periods.

This conclusion helps us to place *Kadırga* in a possible historical context. As we know from historical documents that the straight keel was in use by the beginning of the 17th century, supplanting the rockered keel in galley construction, it is quite plausible to suppose that *Kadırga* could have been built as early as the beginning of the 17th century, and perhaps even earlier.

Conclusion

While still far from being completed, our preliminary investigations indicate that the keel, the end posts, and nearly all of the hull planking have been replaced and the entire vessel has seen significant modifications that have partially altered its original form. Evidence uncovered has yielded some indication as to the vessel's original design. Consequently, while a mid-17th-century construction date cannot be ruled out based on the existing constructional features, a strong argument can be made for an early 17th-century construction, and perhaps one of an even earlier date. However, many questions still have to be answered.

For this reason, future research in the Ottoman archives in Istanbul and continuing study of the structural features of *Kadırga* will be necessary in order to fully understand the history of this fascinating ship.

Acknowledgements

I would like to take this opportunity to thank the staff of the Istanbul Naval Museum whose help and assistance have been invaluable. I also wish to thank Dr George Bass, INA, and especially Dr Cemal Pulak, whose encouragement and support has been inestimable.

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37. Drachio in Context

Louis Th. Lehmann

Baldissera Quinto Drachio (the spelling varies), probably lived from 1532 to 1616 (Gullino, 1992). He worked in the arsenal in Venice as a young man and got in serious trouble with his workmates. He was fired and filled reams of paper with protests, lamentations and advice. He was rehabilitated in 1594. There is little in his writings for students of ships, except in the *Visione* (1593). Here he gives a manual for designing galley-hulls, which in a clumsy way he ascribes to the ghost of his former boss in the arsenal; Francesco Bressan (Drachio, 1593, 3r, ss.), so these rules were probably dictated to him when he was young. This would fit in with the general peculiarity of the *Visione*: all controversial matters touched on date from more than half a century ago and during this period many things had happened that for us have left many questions with very few answers. One of the crucial subjects is still Vettor Fausto's quinquereme, launched in 1529. Drachio calls her: a hospital, a lazaret, even a spectacle of death (Drachio, 1593, 13r). Now this was not unusual in galleys (Concina, 1990: 64–65), until their final years in the 18th century when there was hardly war or navigation for them (Zysberg, 1987: 201, 305, 311–312, 378). Also, the fiver had what is called: a good war-record (Concina, 1990: 64–66). More convincing is that on 13v Drachio condemns the whole "*a sensile*" system of rowing, saying that when you have more than one oar to a bench, the oars are prone to clash.

Fausto was well-read in ancient Greek literature, but it is impossible to claim, as he did, that he learnt how to build a quinquereme after reading about it in ancient Greek books. He can have read the word *penteres* many times. He may have been a mountebank, unless he believed, like later Barras de la Penne (Barras, 9178, 104v), that no other oared vessel than the contemporary galley had ever existed. Now Barras was a rather naive sea-captain, Fausto was not. The only practical problem concerning rowing to be found in Classical Greek literature; the need to have shorter oars, where the ship narrows towards poop and prow, has been formulated by Aristoteles (*De Partibus Animalium*, 687 b 18), and in the pseudo-Aristotelean *Mechanica* (850 b 4) that Fausto himself had translated into Latin.The fact that in galleys this problem had been solved, we do not know when, by means of straight outriggers, viz the sides of a rectangular frame, called telar, laid over the ship, should have warned Fausto. From Polybios he may have learnt what was the crew of a Roman ship of the line in the first Romano-Punic war (I, 26.7). This is generally supposed to mean the crew of a *penteres* but Polybios nowhere says so outright. It is very probable, though, because he tells us that the Romans built a fleet of a 100 *pentereis* and 10 *triereis* (I, 20.9). *Penteres* or not, the ship of the line had 300 oarsmen. Fausto gave his "quinquereme" 280 (Concina, 1990: 77).

Cristoforo da Canal, who in mid 16th century wrote a long treatise with the title *Della Milizia Marittima*, said that the telar laid heavily on the galley and often sagged. He credits Fausto with designing a lighter telar (Da Canal, 1930: 75), so we see that Fausto was familiar with the problems in contemporary galleys and built his "quinquereme" as one. He could have done little else without remaining purely theoretical. A Greek or Roman man-of-war was not built to carry heavy guns and almost all of the frenzied galley-building activity in the Venice of his time was aimed at war.

In galley tradition, Fausto's idea was not even original. Marinus Sanutus, or Marino Sanudo 'il vecchio', in the 14th century wrote a book that was not printed before 1611, and said that when we can put three men on a rowing-bench instead of two, as was done in 1290, we can put four or five there (Sanutus, 1611, LII pars IV caput V–VI). His reason for this proposal was manpower, for he wrote his book with the sole aim to send as many people as possible on a crusade. His statement raises another question: what was your standard man-of-war before 1290? That might have been a vertical "bireme", successor of the Byzantine dromon (Mott,1990)

That oarsmen were traditionally fighting-men too is shown in a fresco, painted by Spinello Aretino, around 1400, in the Sienese Palazzo Publico (Fig. 37.1). There we see oarsmen rowing in helmets in one galley and fighting

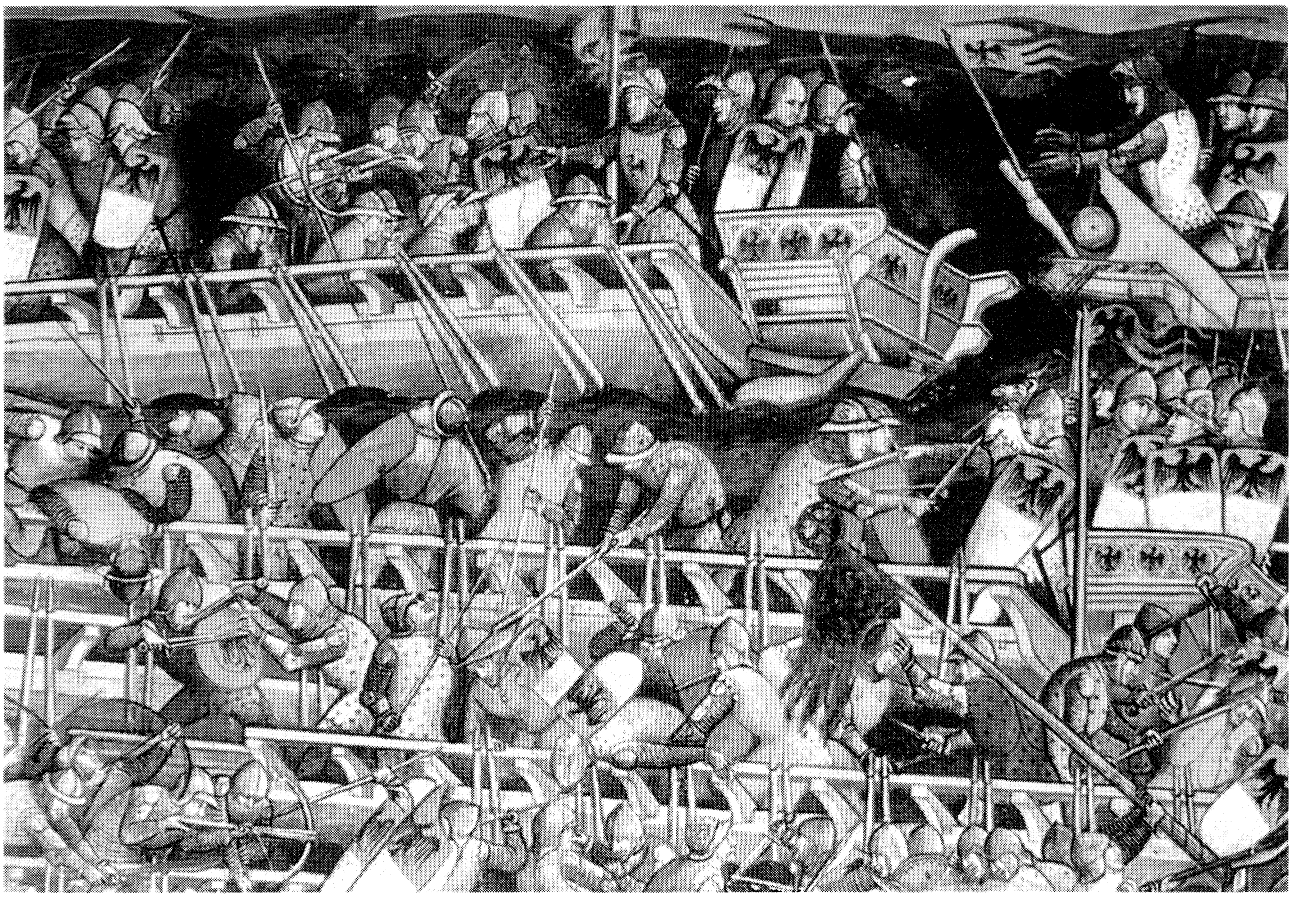
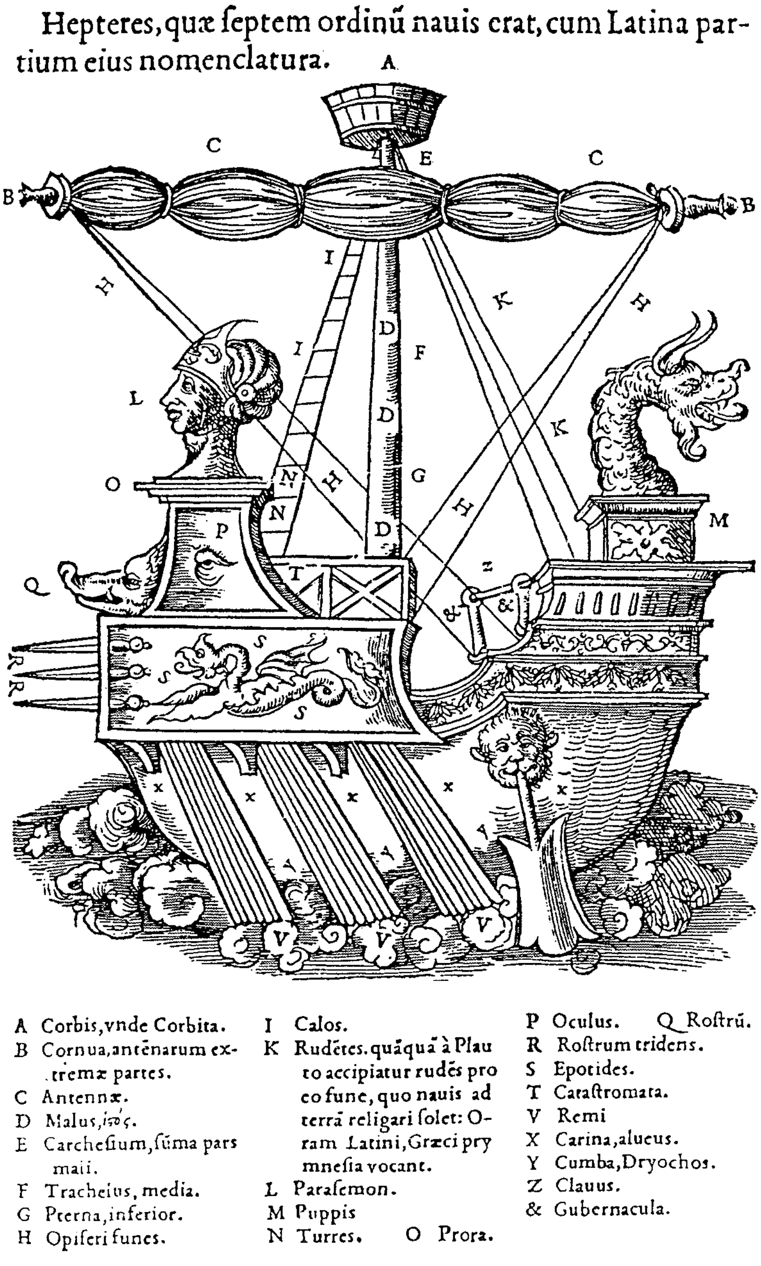


*Fig. 37.1. Fighting-oarsmen on a fresco by Spinello Aretino (*circa *1400), in the Palazzo Publico of Siena (Italy).*

going on in two others, the oars hanging idly. Still in 1580, one Niccolò Surian proclaimed in a very roundabout way that 'for our sins' we need more fighting men, and therefore, have five men at one 'remo grande' (sweep) instead of the old system of three men, each with his own oar, that went so well (Fincati, 1881: 11). Whether the old system really was more efficient we can not tell now, but we can imagine, that a galley smoothly handled by experienced, professional oarsmen, appealed to the sporting, or even aesthetic sentiments of old sea-captains. By this time, convicts rowing galleys had become the rule. Much propaganda had been made for them by Cristoforo da Canal. Among other advantages, like 'they are always there' and 'they cannot bring any luggage' (Da Canal, 1930: 169), he states that convicts have a special way of rowing (who taught them?). Your traditional oarsman, according to Da Canal, uses the same 'get up, sit down' stroke, that was the normal one in the better documented later French galleys (Zysberg, Burlet, 1986). This stroke Da Canal calls "*stroppata*", and he says it is bad for the oarsmen, because the shock of sitting down may damage their brain (Da Canal, 1930: 153–154).[1] But then the convicts! They use a stroke called "*rancata*", they put one foot on a little wooden bar in front of them and '*stanno*' during the stroke. Tenenti (1962: 80) translates this as 'ils sont debout'. Da Canal says that thus the stroke is shorter and faster and that the oarsmen keep their brains intact. It seems highly impossible that men could row effectively standing all the time. This is also Burlet's opinion (pers. comm.).

Da Canal writes with great respect about Fausto, which for all we know may be a 'class attitude'. We have the letter from Pietro Bembo to Ramusio, in which he exults at the proof that an 'intellectual', can be a practical person, in spite of public opinion (Bembo, 1961: 733). Where is Drachio in all this? Probably in the place of a faithful follower of the Bressans, a famous family of shipbuilders working in the Arsenal in the early 16th century, anyway of Francesco Bressan, about whose opinion on rowing-systems we know nothing,but he was "anti-Fausto". The two elder ones, Leonardo and Matteo, had been rivals of Fausto in building a super-warship, but had shown different attitudes towards Fausto (Concina, 1990: 51–52). Drachio paid lip-service to learning, he could produce a plausible sonnet (Drachio, 1595, frontispiece) and quote Latin, but his show of erudition seems to originate in the occultism of the time. Fausto was a learned man, but partly used his learning as a pretence, to 'advertise' his skill in shipbuilding, which insofar as we know, he was the only humanist to have. Other humanists began what we can call nautical archaeology. After a promising start, in 1445, by Leon Battista Alberti (Alberti, 1512, V, 12) in lake Nemi, they took the theoretical way, for which they may be forgiven, ancient wrecks being unknown except for those in lake Nemi, but the result was mostly monstrosities. How could Lazare de Bayf choose this (Fig. 37.2) as an instructive illustration for his book (Bayf, 1537)? He was ambassador of the French king in Venice, where he could see ships every day, and there is ample evidence that he did look at them. Moreover, he knew Fausto (Concina, 1990: 183–186). It was a military engineer, diving, again in lake Nemi, that found, in 1535, one of the most typical features of Greek and Roman ships, that is nowadays used for identifying and even dating, viz the mortise-and-tenon construction. It was published in 1599 and then had to wait almost three centuries to be re-recognized (De Marchi, 1599, II, 82–84). Neither did humanists and their successors contribute much to the development of scientific ship-construction. This was done by craftsmen. In Drachio's time, to design a hull-shape,builders and the 'board of directors' of the Venetian Arsenal looked at some of the most satisfactory ships (Drachio, 1595, 28v.) This the learned called the method of Zeuxis, a Greek painter in the


Hepteres,quæ ſeptem ordinū nauis erat,cum Latina partium eius nomenclatura.

A	Corbis,vnde Corbita.
B	Cornua,antēnarum extremæ partes.
C	Antennæ.
D	Malus,ἱςός.
E	Carcheſium,ſūma pars maii.
F	Tracheius, media.
G	Pterna,inferior.
H	Opiſeri funes.
I	Calos.
K	Rudētes.quāquā à Plauto accipiatur rudēs pro eo fune, quo nauis ad terrā religari ſolet: Oram Latini,Græci prymneſia vocant.
L	Paraſemon.
M	Puppis
N	Turres.
O	Prora.
P	Oculus.
Q	Roſtrū.
R	Roſtrum tridens.
S	Epotides.
T	Cataſtromata.
V	Remi
X	Carina,alueus.
Y	Cumba,Dryochos.
Z	Clauus.
&	Gubernacula.

Fig. 37.2. Illustration from Lazare de Bayf's book (1537).

5th or 4th century B.C., who, when asked to paint an Aphrodite for the city of Croton, demanded first to inspect some of 'the prettiest girls in town' (Concina, 1990: 156, 164, n.69) . This evidently was a wandering anecdote. Pliny the Elder locates it in Akragas (Plinius Maior, XXXV,54.). The method could be definitely shelved when in the late 18th century the Swedish shipbuilder Frederik Henrik af Chapman invented the testing tank (Harris, 1989: 82–83, 168–170).

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Notes

[1] This looks as if he, a commander, never had rowed. Even rowing a small boat one feels like hanging from oar or sculls.

38. Variations on a Theme: 11th-century Ship Types of the North

Ole Crumlin-Pedersen

Introduction

The present paper will focus on ship types of the 11th century as reflected in the presently available, well-dated archaeological evidence from the coastal zone of Denmark and the neighbouring coasts of Norway, Sweden and Germany. In order to increase the number of specimens for comparison between the different groups of vessels, the time frame has been expanded by half a century at both ends.

From this period, 950–1150 AD, as many as twenty wrecks (Table 38.1) are known to us in sufficient detail for these vessels to be classified according to date, size, origin, general character and technology. They are marked out on the map (Fig. 38.1) with an S for ship find. The degree of preservation for each of these twenty ships varies between 20% and 80%, and several of them have been intensively studied over many years. Fully-functional reconstructions of seven of the ships have been built and tested under scholarly control and one more of these reconstructions is currently under construction in Roskilde.

In addition to these twenty ship finds there is a considerable number of other finds of less-well-preserved wrecks and assemblages of timbers from boats and ships which have been found in blockages, at the site of scrapping-yards or waterfronts, and in cemeteries. A total of ten sites of this nature with the remains of numerous ships and boats have been identified and partly published from within the same area and time span, marked out on Fig. 38.1 with an A for assemblages.

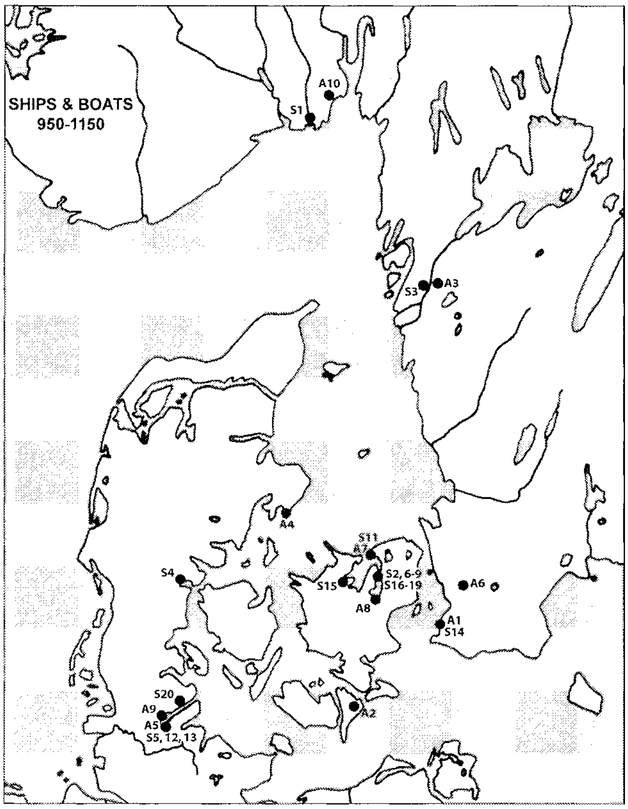

Fig. 38.1. Map of the distribution of finds of boats and ships (S) as well as of assemblages of ships' parts and badly preserved vessels (A) of the period 950–1150 from the Danish waters and the surrounding coasts.

Evidently there is a relatively high frequency of finds of this nature from the area and time span chosen here, and there are several other ship finds dated shortly before or after this period, as for example the *Ladby* ship from the first half of the 10th century (see Bischoff, 2003), and the large cargo vessels of the period up to 1250 (see Englert 2003). These finds illustrate a range of variations but also lines of continuity in the ship types over this time span. Thus there is a strong body of archaeological and experimental evidence on which to base the discussion of 11th-century ship types in this central area at the crossroads of the routes between the Baltic and the North Sea, and between Scandinavia and Central Europe.

The basic concept

In 1962, as the five Skuldelev ships of the 11th century were excavated, they proved to be of widely differing

S no.	Site/country	Date	Origin	Found	Excav.	Context	Length	Type	Capacity	Reference
1	Klåstad/N	c. 1000		1893	1970	wreck	21 m	CaSc	c. 13 t	Christensen, Leiro, 1976
2	*Skuldelev 1/DK	c. 1030	W. N	1924	1962	barrier	16.3 m	CaSc	24 t	Olsen, Crumlin-P., 1968
3	*Äskekärr 1/S	c. 1000	S-W. S	1933	1933	wreck	15.8 m	CaSc	c. 20 t	Humbla, 1934; Bråthen, 1998
4	Eltang/DK	1140+	W. DK	1943	1947	wreck	c. 18 m	CaSc		Skov, 1952; Englert, in print
5	Hedeby 1/D	c. 985	W. Baltic	1953	1979	wreck	30.9 m	PeSc	c. 60 oars	Crumlin-P., 1997
6	(*)Skuldelev 2/DK	1042-43	Dublin	1957	1962	barrier	c. 30 m	PeSc	c. 60 oars	Olsen, Crumlin-P., 1968; Bonde, Crumlin-P., 1990
7	*Skuldelev 3/DK	1030-50	DK	1958	1962	barrier	14.0 m	CaSc	4.6 t	Olsen, Crumlin-P., 1968; Andersen *et al.*, 1997
8	*Skuldelev 5/DK	1030-50	DK	1958	1962	barrier	17.5 m	PeSc	26 oars	Olsen, Crumlin-P., 1968; Crumlin-P., 1988
9	*Skuldelev 6/DK	1030-50	W. N	1959	1962	barrier	11.6 m	BoSc	2.5/5 t	Olsen, Crumlin-P., 1968
10	Ralswiek 2/D	977+	S. Baltic	1967	1967/93	wreck	9 m	BoSl	10 oars	Herfert, 1968; Fircks, 1999
11	Lynæs 1/DK	c. 1142	S-W. S	1975	1975	wreck	c. 25 m	CaSc	c. 57 t	Crumlin-P., 1979; Englert, in print
12	Hedeby 2/D	965+	W. Baltic	1980		wreck	9-12 m	BoSc/Sl		Crumlin-P., 1997
13	Hedeby 3/D	1025	W. Baltic	1981		wreck	c. 22 m	CaSc	c. 60 t	Crumlin-P., 1997
14	*Fotevik 1/S	1050-1100		1981	1982	barrier	10.3 m	BoSc	12 oars	Crumlin-P., 1984
15	*Gislinge/DK	1130-50		1993	1993	wreck	7.5 m	BoSc	6 oars	Gøthche, 1995
16	Roskilde 3/DK	1060+	W. Baltic	1997	1997	wreck	18 m	CaSc	c.11 t	Bill *et al.*, 1998
17	Roskilde 4/DK	1108		1997	1997	wreck	c. 20.5 m	CaSc	50-60 t	Bill *et al.*, 1998
18	Roskilde 5/DK	1130		1997	1997	wreck	14 m	CaSc	c. 5 t	Bill *et al.*, 1998
19	Roskilde 6/DK	1025+		1997	1997	wreck	c. 36 m	PeSc	c. 78 oars	Bill *et al.*, 1998
20	Karschau/D	1130+	W. Baltic	2000		wreck	22-25 m	CaSc	50-60 t	Englert *et al.*, 2001

D = Germany
DK = Denmark
N = Norway
S = Sweden

Bo = Boat (under 12 m)
Ca = Cargo vessel
Pe = Personnel-carrier

Sc = Scandinavian features
Sl = Slav features

* = replicated

Table 38.1. Ships and boats, dendro-dated to the period 950–1150, found along the Danish shores and neighbouring coasts.

character representing five different ship types (Crumlin-Pedersen, Olsen, Eds. 2002). They all, however, shared certain features representing the basic concept of the clinker tradition. This is also the case for all the other vessels presented here, whereas they differ in other aspects.

The common clinker concept during that period included the following features: a double-ended hull based on a keel, a curved stem fore and aft, and a shell of relatively thin overlapping planks fastened by rivets or small treenails. The shell was supported internally by a system of transverse timbers arranged symmetrically port and starboard with a regular spacing, and in some cases also with two or more longitudinal stringers.

This complex of features is shared by all seagoing planked boats and ships found along the coasts of the Baltic Sea and dated within the period from the end of the Roman Period to the beginning of the 12th century AD. Among the recorded finds dated within this period there are no "cogs" or any other seagoing vessels representing basically different boat-building concepts. These finds are all variations on a theme which we may refer to as "Nordic" if by this term we include the products of boatbuilders from areas in the North Sea and the North Atlantic settled by people of Scandinavian descent, as well as along the entire coastal zone of the Baltic Sea, settled by populations of Scandinavian, German, Slav, Baltic or Finnish origin.

Date and origin

In most cases, the crucially important information on the date and the origin of the vessels can now be determined by independent natural scientific methods, primarily by dendrochronology – at least for ships from within Northern Europe. Therefore there is no longer need to use typology sequences with the aim of dating the finds. Today we are free to study the differences in shape, size, structure and craftsmanship independently, and to try to relate these features to the original context, function, status and individual history of each of the ships.

Size and general character

In Table 38.1, the recorded or estimated original overall length of each of the vessels (the S-finds in Fig. 38.1) is given, with a length of 12 m as the dividing-line chosen in order to distinguish between boats and ships. When possible, the number of oars or the calculated or estimated cargo capacity is also given.

For these vessels it is relatively easy to distinguish between those built as warships and those which were build primarily for the transport of cargo. During this period the former were relatively long and narrow, with a deck in the full length of the ship and several oars, whereas the latter were more strongly built, with greater beam and depth in relation to their length, and with a cargo space amidships. For the boat category a similar distinction cannot be drawn, as these were often multipurpose vessels.

Tradition and craftsmanship

Careful recording and analysis have been undertaken of all recovered parts of these vessels. This has enabled the investigators to identify differences in the standard of work, reflecting different status levels for the ships, as well as aspects of the individual history of each vessel (see Crumlin-Pedersen, 1997; 2002). In order to distinguish in this brief presentation between Scandinavian and Slav features, the plank-fastenings are used as a general guide, taking the primary use of iron rivets or small treenails in this period as attributes of one or the other origin respectively.

Having classified the twenty ships and boats in Table 38.1 according to these criteria, we can study the pattern they describe when plotted within intervals of 25 years (Fig 38.2). Here the second quarter of the 11th century dominates, primarily because the five ships from the Skuldelev complex are all dated within this period. Even the 25-year-periods up to the years 1000 and 1150 have concentrations of finds but in these cases the finds are all from different sites. In general none of the quarter-century-intervals within the 200-year-period is without finds. Warships are known only from the first half of the period, whereas cargo vessels and boats are represented in each half century, the cargo ships with an increase in number towards the end of the period.

On the plot of the sizes of the vessels within 3-m-categories (Fig. 38.3), the boats are assembled below the 12-m-line according to the criteria used. In the ship-category all finds of a length up to 27 m, with the exception of the *Skuldelev 5* ship, are cargo ships. At the upper end of the scale, all three finds are proper longships. Thus the warship group is represented by the three longships at the top and the smaller ship in the middle, the cargo ships are all in the middle group and only increase slightly in size towards the end of the period, and the boats are relatively evenly spread within the period.

At this stage it is necessary to touch on the problem of the representativity of these finds. When compared to other regions and other early periods, twenty well documented and analysed vessels is a high frequency of ship and boat finds, coming from different sites and contexts and corresponding to one for each ten years on average. Still, we cannot conclude, on this evidence alone, that there were no warships in the later part of the period, that

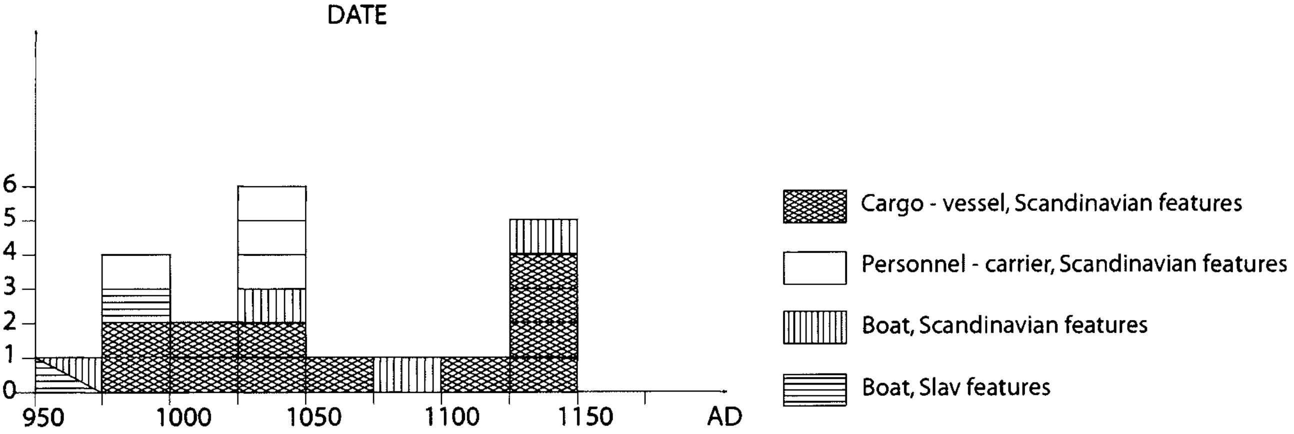

Fig. 38.2. Twenty wrecks from 950–1150 AD: the date of the ships and boats in Table 38.1.

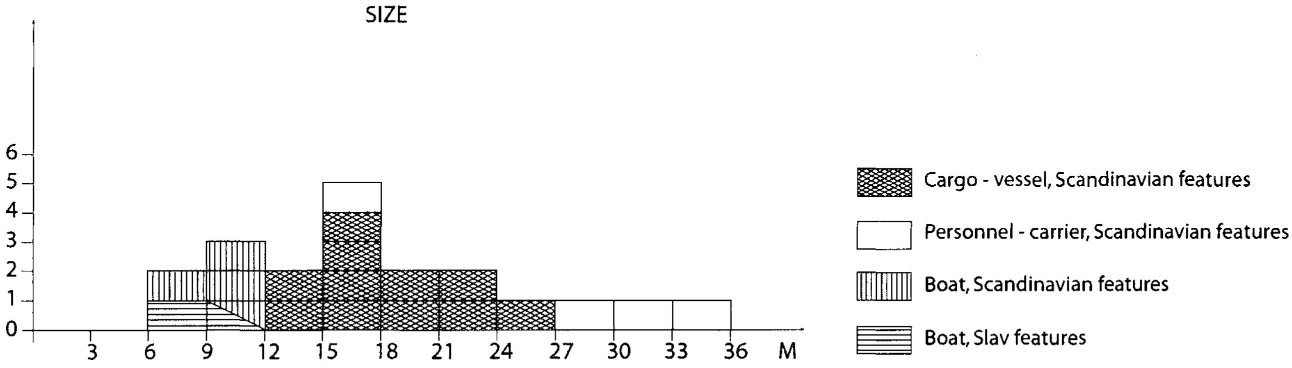

Fig. 38.3. Twenty wrecks from 950–1150 AD: the length of the ships and boats in Table 38.-1.

there were no large ships of Slav tradition, or that the Scandinavian cargo ship type did not develop further in size during the 12th century than illustrated in these finds.

Nor can we exclude the possibility that some types of ships and boats that sailed these waters a millennium ago are missing from the finds. However, the several less-well-preserved wrecks and assemblages of ship and boat parts (the A-finds in Fig. 38.1), representing a variety of other sites and contexts, supply no evidence of basically different types of plank-built vessels for navigation on the open sea during this period.

At this stage, the substantial evidence resulting from the archaeological analysis of these twenty ships may be confronted with the evidence from contemporary written and iconographic sources. Not for lack of confidence in our archaeological methods or results, or from a desire to be 'spoon-fed' by other disciplines, as recently stated by some archaeologists (Maarleveldt, 1995; Weski, 1999). On the contrary, we can do so in recognition of the fact that the evidence resulting from a thorough analysis of the high-quality source material of ship archaeology may serve as important primary evidence, carrying considerable weight in its own right, for studies into economic and political history in addition to its contributions to archaeology in general (Crumlin-Pedersen, 2000).

In our case, focusing on the ship types of 11th-century Northern Europe, several names for these are known from the Norse sagas (Falk, 1912). These were written down at a later stage during the Middle Ages, however, so that they may have incorporated terms for ships and for features related to these that had not yet come into use in the 11th century or had been altered since then. There are other ways, however, to establish that several of the names for ship types were actually in use at this earlier stage, for instance when they are found in contemporary English and Continental sources, or in runic inscriptions and scaldic verses composed in the 10th and 11th centuries, see Table 38.2 (Malmros, 1986; Ridel, 2001).

As is well known from later periods, however, the ship types of the North were not defined once and forever; they gradually changed character and size to suit new needs and aspirations of their owners without changing the type term. Thus a royal longship of the 11th century was characterised in the contemporary scaldic verses by its great length and slender construction and its speed-potential, which was superior to that of more ordinary warships. In contrast, the royal ships described in the 13th-century saga texts are praised for their large size with great beam and high sides, and from the description of the manoeuvres it is evident that the accompanying ships were smaller and faster than these (Malmros, 1986: 111).

In a way this transformation of the largest warships in the 12th and 13th centuries brought these back to the standards they had had before. The few Early-Viking-Age finds known to us, especially the Gokstad ship, indicate that in the 9th and early 10th centuries the warships may have been much broader than their equivalents of the 11th century, and even have had a moderate cargo capacity (Crumlin-Pedersen, 1999). This change in proportions is also reflected in some of the type terms.

In some early cases the word *knörr* is used about warships, but later this term is applied for cargo carriers exclusively – and in two cases it appears as an element in a nickname, *knarrarbringa,* used of Icelandic women with a bosom like a *knörr* (Falk, 1912: 109). This is an interesting example of how particular aspects of the female anatomy may help us to link terms from the written sources with evidence from archaeology and iconography.

In this case we have a Viking-Age term, *knörr*, used for a ship type which evidently had a very full bow, a ship (*Skuldelev 1*) built in western Norway in the 11th century with an in-curved bow with 'tumble home' character of the upper planks, and a graffito of the 12th century from the same area, evidently depicting a ship of precisely this type (Fig. 38.4).

In other cases we do not possess such remarkable criteria for matching the type terms with the archaeological finds. We can, however, divide our twenty ships into groups according to their size and function and relate these to type terms known from the written sources. By doing this we can see that the main division line between cargo ships, warships and boats, established on the basis of archaeological criteria, corresponds to the terminology of contemporary writers when they used the words *kaupskip, herskip* and *bátr.*

The larger group of the cargo ships may be characterised

Cargo ships:	
kaupskip, céapscip:	'merchant's ship'
storskip:	'large ship'
hafskip:	'seagoing ship'
knörr, cnear:	medium or large ship with 'bosom-like' stem
búza:	large (war and) cargo ship type
byrðingr:	medium or small-sized cargo ship
skúta:	medium or small-sized multiple-purpose ship
ceól, kjóll:	English cargo ship
hulc:	term for Frisian cargo ships in English sources
Personnel-carriers (warships):	
herskip:	'army ship'
langskip:	'long ship'
leiðangrsskip:	warship supplied by the *leidangr* organisation
skeið, scegð:	large warship
dreki:	'dragon ship'
æsc, askr:	English term for Viking warship
snekkja:	medium or small Scandinavian warship
-sessa:	ship type described by its number of rowing benches
Boats:	
karfi:	small or medium-sized Norwegian vessel for personnel transport
ferja:	small or medium-sized vessel, primarily for goods transport
-æringr:	boat type described by its number of oars

Table 38.2. Terms for ship types of the North, 10th–12th century (after Falk, 1912; Malmros, 1986)

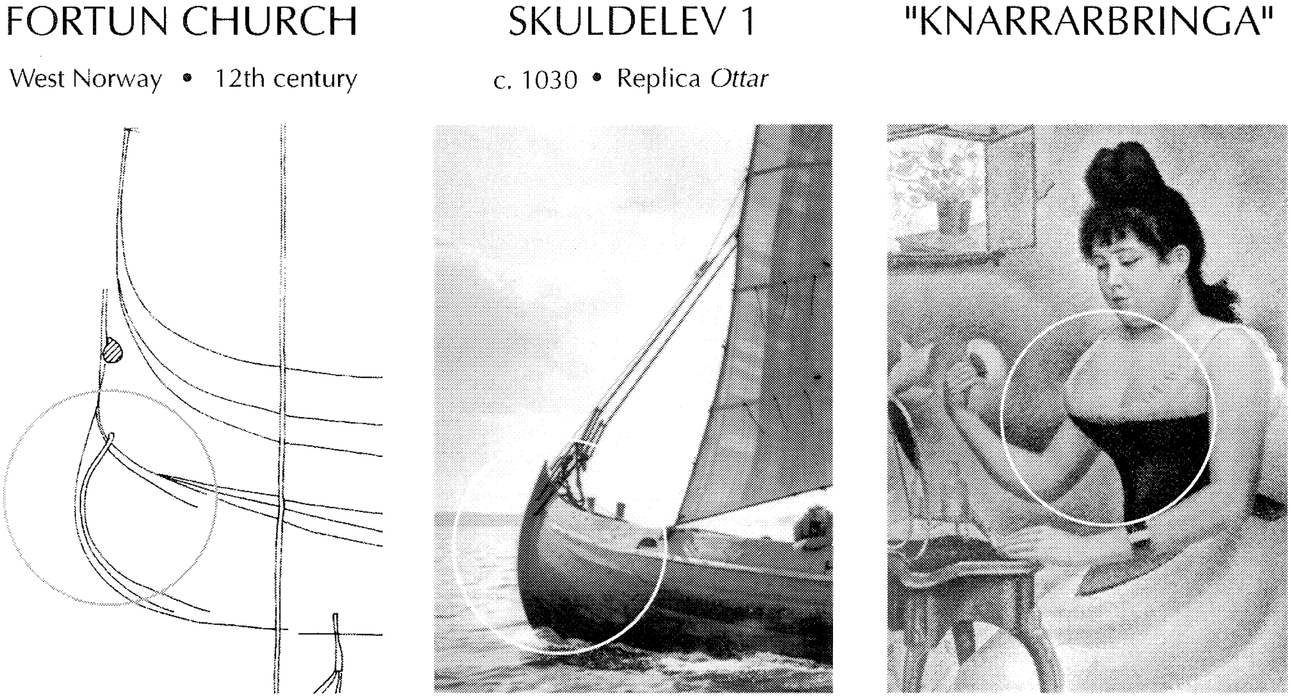

Fig. 38.4. Two Medieval Icelandic women were nicknamed knarrarbringa *(*bringa *"breast, bosom"), and in northern Norway the term* knarrstemnd *was used to characterise vessels with a tumble home bow. On this background* Skuldelev 1 *has been identified as a* knörr. *Here the* Ottar *reconstruction of* Skuldelev 1 *is shown together with an incised stem of similar character in the 12th century stave church from the Sognefjord region of western Norway (photos: W. Karrasch, M. Blindheim).*

by their size as *storskip*, by their seaworthiness as *hafskip* or by their shape and other features as *knörr* or *búza*. For the lower end of the scale, the ships may have been called either *byrdingr* or *skúta*. This leaves a rather narrow margin for the matching of this group of ship finds with the general terms and the specific type terms within the terminology used during that period.

For the warships, the situation is similar. Evidently they could all be called *langskip* from the largest size down to the 26-oared vessel. This indicates that the term *lang*/long refers to the length of the vessel in relation to its width, rather than to its absolute length. The *Skuldelev 5* ship, representing the smallest longship size, would most likely have been called an *æsc* in England, a *snekkja* in its home country Denmark, and it could have been referred to as a *leioangsrskip* if it was part of the defence system for its home waters. The three ships in the 30-m-class would have been called *skeid* in Scandinavia or its anglicised form *scegd* in the British Isles, or they could be called *dreki* with reference to their dragon-like appearance with figurehead, ornamentation and the sail as the wing of the dragon.

The plank-boats were called *ferja* or *karfi*, or they were simply characterised by the number of oars worked from each boat, from 4 up to 12 oars. According to this system the small Gislinge boat was a *sexæringr* and the larger *Fotevik 1* a *tolfæringr* (referring to six and twelve oars respectively).

Using the five Skuldelev ships as examples, it is now possible to present all of these in reliable and fully functional reconstructions on the basis of the analysis of the archaeological evidence and the experimental activities. When taken one by one, they bring us around far and wide and play many roles (Crumlin-Pedersen, Olsen, Eds., 2002):

- *Skuldelev 1:* the dendro-analysis has shown that this medium-sized cargo ship was constructed with a planking of pine that was felled shortly after 1030 in the Sognefjord region of western Norway. This ship with its characteristic full lines with tumble home in the bow was probably a *knörr.* Later it was repaired more than once with oak planks from the Oslo Fjord region and from southern Sweden or eastern Denmark, indicating that it was more specifically an *austrfararknörr*, the ship type constructed for the Baltic trade, which was smaller than those normally used on the North Sea and the Atlantic. A first full-scale reconstruction of this ship, *Saga Siglar*, was built in Norway in 1982–83, and circumnavigated the Globe before it was lost during a storm in the

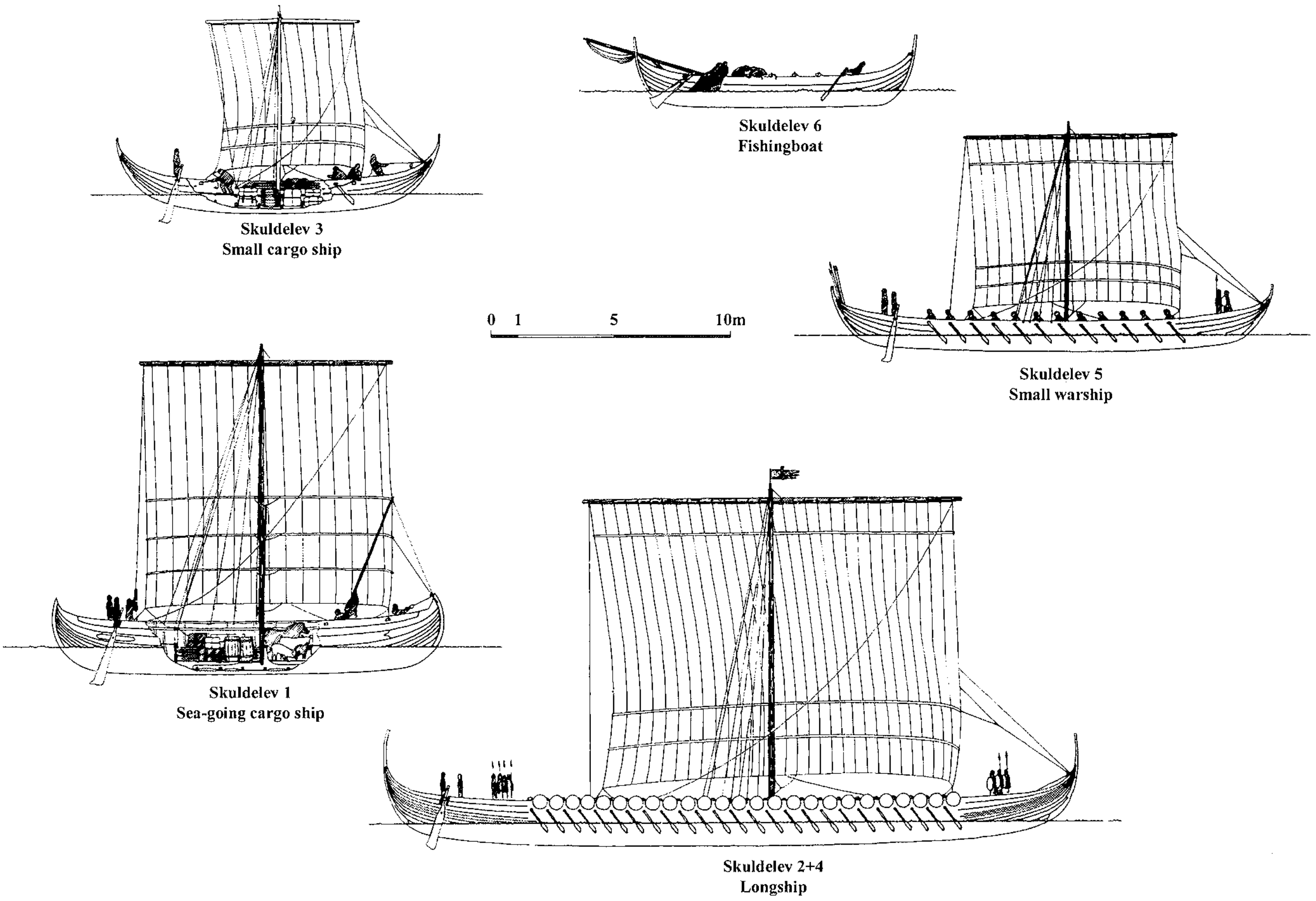

Fig. 38.5. The five Skuldelev ships in outline reconstructions (drawing: Morten Gøthche).

Mediterranean in 1992. After the conclusion of the final analysis of *Skuldelev 1,* a proper replica, *Ottar,* was built in Roskilde and launched in August 2000.

- *Skuldelev 6:* this large boat was constructed at the same time and in the same area of western Norway as *Skuldelev 1,* possibly for fishing purposes, but it was modified with an extra strake before it sailed to Denmark, maybe even in company with the *knörr.* Originally it may have been called a *ferja,* as this term was used for vessels carrying fish or modest quantities of other goods. A reconstruction of this vessel, *Kraka Fyr,* in its first version without the extra washboard was built in Roskilde in 1997–98.
- *Skuldelev 3:* this small Danish ship, built circa 1040, was a multipurpose coastal vessel, ideally suited to match the transport requirements of a Viking-Age farmer and his household for going to market with the products of the farm, or for transport to the *thing* or to religious gatherings. This vessel was probably originally referred to as a *byrdingr* or *skúta.* The construction of the replica of this ship, *Roar Ege,* was carried out in 1982–84 in Roskilde as the first major reconstruction project of the Viking Ship Museum in which it was endevoured to use only authentic tools and materials (Andersen *et al.,* 1997).
- *Skuldelev 5*: this 26-oared Danish warship is peculiar in its construction, as it was built circa 1030 from a mixture of new and old materials and had been repaired over and over again. The standard of building was far below what would have been expected if the vessel was intended for use as the personal ship of a Viking chieftain but it matches perfectly the text on the *leidangrsskip* in early 12th-century Norwegian legislation, the *Gulathing* law (Crumlin-Pedersen, 1988). *Snekkja* was doubtless the term used for this ship type as it has been preserved in numerous place-names around the Danish coasts, possibly at those locations where the *leidangrsskip* was kept during the winter (Holmberg, Madsen, 1998). The reconstruction, *Helge Ask,* of this ship was built in Roskilde in 1990–91 – although not from reused ships' planks so that it now appears to be of a better standard than the original ship was, even as a new vessel.
- *Skuldelev 2 (+4)*: according to the dendro-analysis this circa 30 m-long ship for 60 rowers was built in 1042 in the Dublin region of Ireland, and a repair to the

Cargo ships:					
11	Lynæs 1/DK	c. 25 m	*knörr, búza*	*storskip, hafskip*	*kaupskip*
20	Karschau/D	22–25 m			
13	Hedeby 3/D	c. 22 m			
1	Klåstad/N	21 m			
17	Roskilde 4/DK	c. 20.5 m			
4	Eltang/DK	c. 18 m			
16	Roskilde 3/DK	18 m			
2	Skuldelev 1/DK	16.3 m			
3	Äskekärr 1/S	15.8 m	*byrðingr, skúta*		
7	Skuldelev 3/DK	14.0 m			
18	Roskilde 5/DK	14 m			
Personnel-carriers (warships):					
19	Roskilde 6/DK	c. 36 m	*skeið, dreki*	*herskip, langskip*	
5	Hedeby 1/D	c. 30.9 m			
6	Skuldelev 2/DK	c. 30 m			
8	Skuldelev 5/DK	17.5 m	*askr, snekkja, leiðangrsskip*		
Boats:					
9	Skuldelev 6/DK	11.6 m	*ferja?*	*karfi?*	*bátr*
14	Fotevik 1/S	10.3 m	*tolfæringr*		
12	Hedeby 2/D	9–12 m	*?*		
10	Ralswiek 2/D	9 m	*?*		
15	Gislinge/DK	7.5 m	*sexæringr*		

Table 38.3. Matching the ship-finds with terms from the written sources for the twenty boat and ship-finds from the period 950–1150.

planking in the 1060s was evidently also carried out in the Irish Sea region. After that the longship came to Roskilde and was scuttled at Skuldelev, evidently in the 1070s. No doubt this ship-type was called *skeid* or *dreki* among the Vikings in Ireland as well as in Scandinavia. Only about one quarter of the planks and timbers of this ship have survived but enough to determine the main dimensions and basic structure of the ship. Work on the building of a full-scale reconstruction of this ship is now underway in Roskilde, with a planned launching date for the longship in 2004.

As has been demonstrated here, a match is possible for each of these five ships as well as for the remaining fifteen ships in this survey with one or two terms for specific ship types known from the written texts, thus providing evidence of a much higher quality as to the character of each of these types than the contemporary written sources can possibly give. Thus this source of evidence offers a unique contribution to the history of shipbuilding and seafaring of the period. This archaeological evidence may then help historians to gain new insight into aspects of the ancient texts or artwork and thus improve the basis for writing, on an interdisciplinary basis, the maritime history of the Middle Ages.

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39. The Boat *Puck 3* in the Light of Investigation of Other Slavic Boats from 9–14th Century

Jerzy Litwin

The archaeological position on the Puck Bay was discovered in 1977 by scuba divers – amateurs who came across constructions made of oak logs and a wreck of an ancient boat on small depths (Stępień, 1984). The range of the appearance of the monuments, the majority of which come from the early Middle Ages, occupies approximately 12 hectares. During the systematic excavations of the seabed of the Puck Bay, carried out between years 1977 and 1985 by the Puck Museum, numerous relicts, especially the wrecks of three vessels, a small logboat and single construction elements of a craft from 6–13th century were founded (Stępień, 1984). After 1985, there was a break in the excavation works and only the observations of the preservation state of the monuments, however, led to the decision about raising the ones being most endangered in order to secure them. Keeping with this, the log-boat was raised in 1989. The divers simultaneously brought three a floor-timber, a stem from a small boat and a bailer encountered near the place of the operation (Litwin, 1995: 139).

The wreck of the boat *Puck 3* (Fig. 39.1) that was lying obliquely on the seabed of the bay with one end and its split planking around 50 m beneath the water line, while the other one, with the end of the stem, hardly visible in

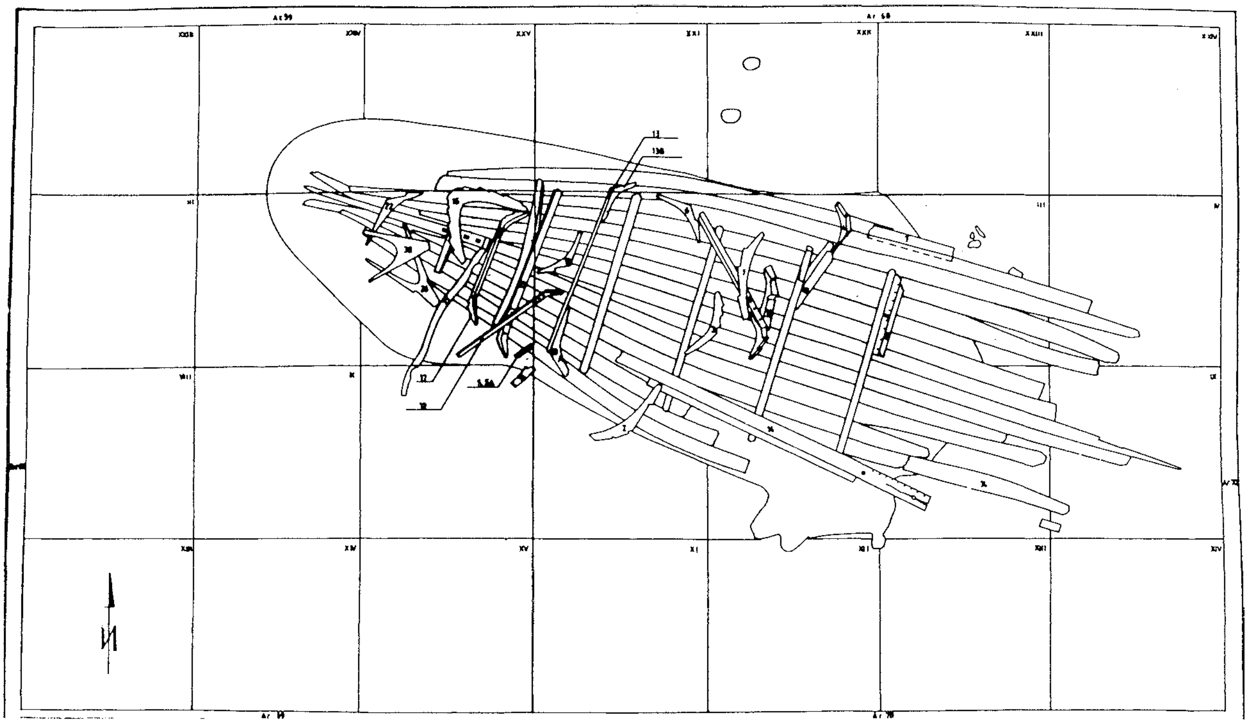

Fig. 39.1. Wreck Puck 3 *before raising in 1990 (with its few elements lying on an upper level of the site) (drawing on the basis of documentation elaborated by Iwona Seweryn).*

the thick layer of mud and peat, was raised in 1990 by our Museum managed at that time by P. Smolarek. While the wreck number 3 was unearthed, another one, marked with a symbol P-5, was founded. This is a relic of a boat over 12 m long, lying approximately 1 m beneath the seabed. The monument was partly recognised only. It was established that the boat had been built with the method typical of the Slavic boat-building art in the middle of 13th century and it was secured on the position (Litwin, 1995: 140–142).

At present, the process of *Puck 3* conservation is drawing near to the end, while the studies on that monument are advancing. Among other things, a conceptual model of this boat was performed in the scale 1:10 and the idea of the initial hull assembly was worked out (Fig. 39.2). On the account of the analysis of the wreck *P 3* it was possible to study other remains of Slavic boats, such as the boat *Orunia III* discovered in 1934 and worked out by Otto Lienau (Lienau, 1934). They both evince similarities in the construction technique, while the better state of the *Puck 3* shows also hitherto unknown elements of construction were not recognized by O. Lienau. Assuming then the original similarity of the boats, one may make a decisive verification of Lienau's attempt at reconstruction of the boat *Orunia III.*

The dendrochronological examinations of these monuments enabled us to specify prior date arrangements, reached with the method C14, which proves that *Orunia III* was built in the third quarter of 12th century. The *Puck 3* boat is dated to not earlier than the beginning of the second half of 12th century.

Because of the shortage of time for this presentation, I will now proceed to the analysis of the keels, stems and the planking of the boat *Puck 3*. The keel has been preserved approximately in 2/3 (two thirds) of its length, is T-shaped in cross section and relatively low and wide. At its end there is a side, diagonal cut serving to link the stem. The stem is an important structural element of the boat *Puck 3*. Such units appear on the excavation positions of early medieval Slavic boats rather rarely. Moreover, a wreck of this kind with two stems preserved has not been found yet. There was usually one of them, as was the case with Orunia in 1934, where each of the three wrecks possessed a stem in a different shape (Fig. 39.3) (Smolarek, 1969: 249) that can serve as a sample for the further specification. Therefore, the stem from the boat *Orunia III* may be treated as a model one for the group of the boats with a such shape of stems. The stem from the boat *Puck 3* (Fig. 39.4) recognized as the stempost, preserved in the major part, represents a simplified version, with no rabbets for the ends of the planks, which feature is present in other stems known to us, as for example in *Orunia I* and *Gdańsk II.* The stem *Puck 3* was made from an one crooked pice with the external radius approximately 3.6 m long, shaped triangle-like in the cross section and narrowing gently to its point. From the side, near the scarf with the keel, there is a "stair", present very frequently in such elements from the wrecks of other, not merely Slavic boats. However, the arrangement of fastening the planking with the stem is only noticeable in the wreck of the boat *Puck 3.* Such an element, probably in an earlier form, is known from the craft *Orunia I* and *Gdańsk II.*

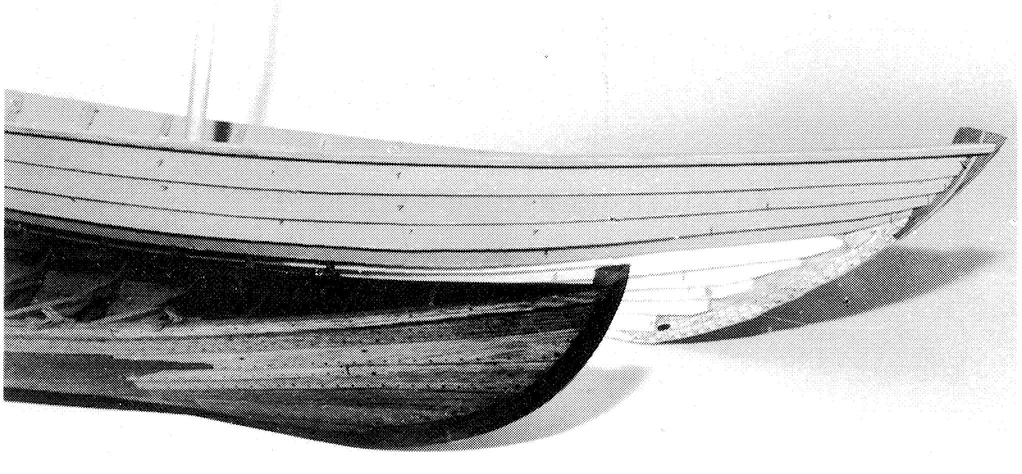

Fig. 39.2. Two bows of models – the Orunia III *boat made on a base of O. Lienau's drawigs and the bow of the study model of the* Puck 3 *boat with a connector for the lower planking.*

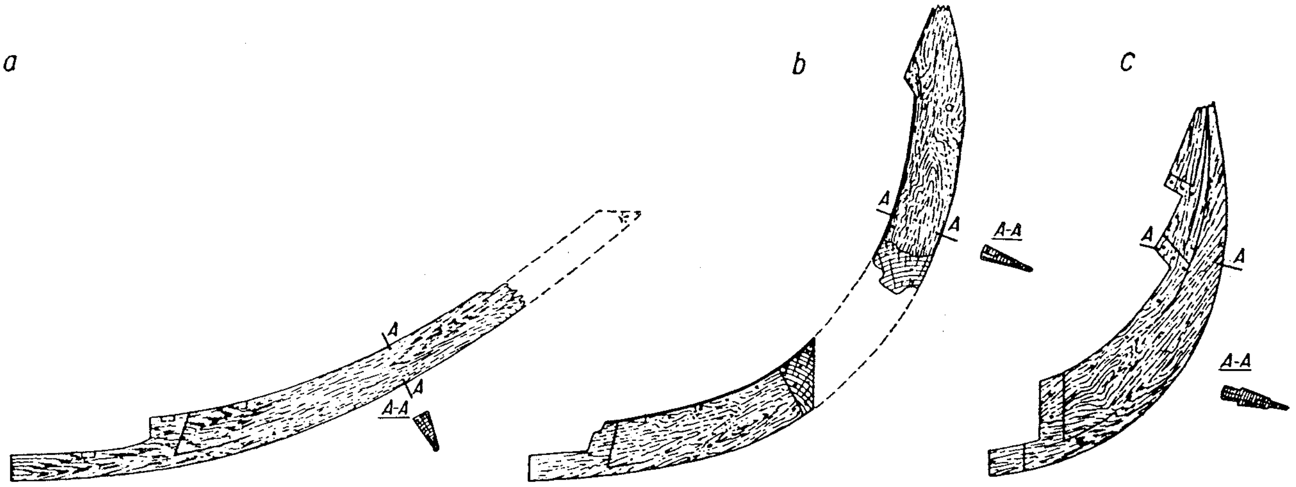

Fig. 39.3. Three different stems from Orunia *wrecks: a) the stem from* Orunia III *boat; b) the stem of the* Orunia II *boat; c) the stem of the* Orunia I.

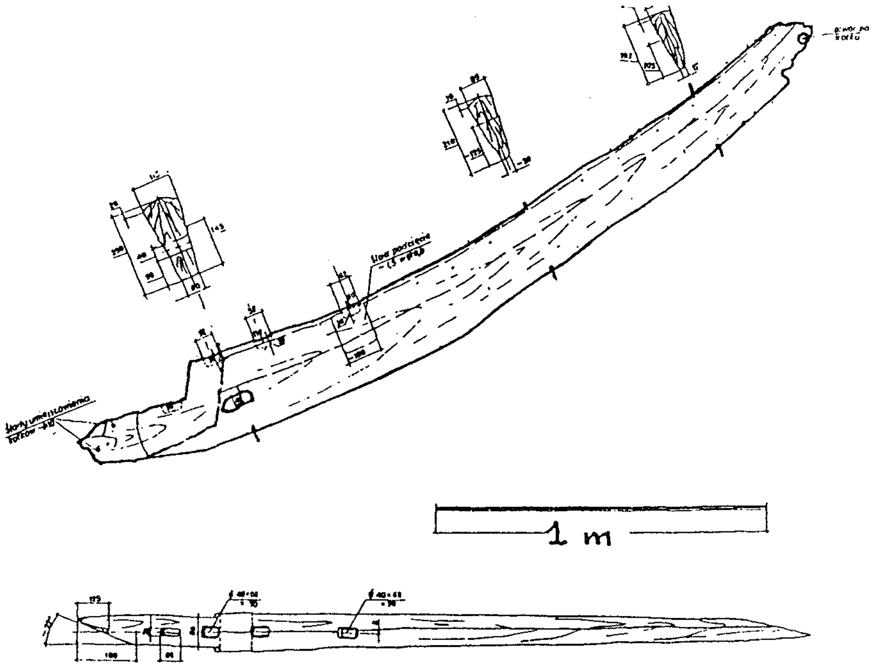

Fig. 39.4. The stempost from Puck 3 *boat belongs to the* Orunia III *boat's stem group.*

It was by nature difficult to be made because of the necessity to groove the plane of the stem from the inside of the hull and shape the necessary number of symmetrical rabbets for the ends of planks. Unfortunately, in case of damaging such a stem, a repair would be very difficult and, it would be also impossible to reuse this stem in another boat. The fact, that the recirculation of elements and stems in particular was common. It is confirmed by the lack of such parts in the majority of wrecks. It follows that a stem with rabbets, as for example the one from the vessel *Orunia I*, which can be seen on the example of the stem from *Puck 3*, was exchange by an ordinary, naturally crooked log, to the sides of which adequately profiled as an innowation wooden elements – "connectors" – which were hammered with iron nails. These "connectors" – containing rabbets for the lower ends of planks (Fig. 39.5). The upper surface of the stem evinces also other details, present in the stem of the boat *Orunia III* and the one from a small boat, raised from the seabed of the Puck Bay, as well. These are perpendicular-like shaped hollows, used only in the process of assembling the first and second strakes of planking in order to handle them with pincers to

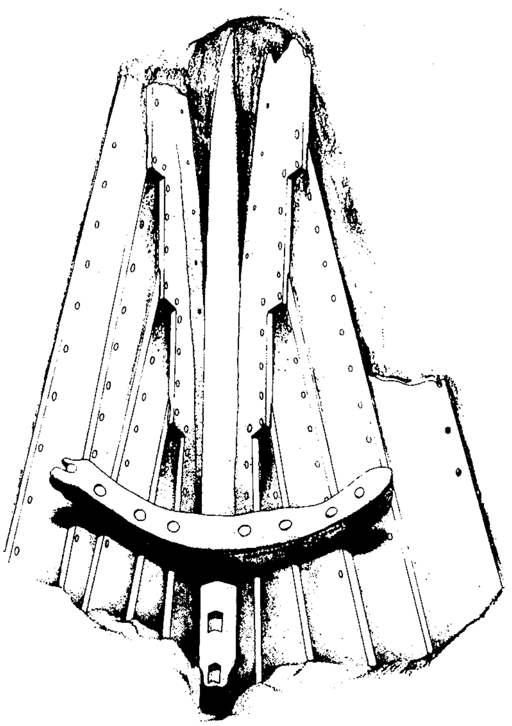

Fig. 39.5. The axonometric drawing of the inner side of planking and "connectors" in the bow of the Puck – 3 *boat (drawing: W. Stępień).* Gdańsk

the stem and facilitate the operation of joining the elements with wooden pegs. Similar two hollows appear in the axle of symmetry in the front part of the keel in the *Puck 3*, while in the keel of *Orunia III*, whose both ends are preserved, there are seven such hollows of different arrangements on each side. At present we can only speculate on the form and appearance of the upper part of the stem exemplified in *Orunia III*. As a result of decreasing the sizes of stems from the keel upwards – to the upper part of the stem, there was no possibility to join upper strikes directly to the stem, that would have reached there the side surfaces of the stem at a big angle. For this reason, there had to be other solutions in use; most probably "extra connectors", similar to those applied in the lower part of the planking. Owing to the analysis of the structural elements of the boat *Orunia III*, compared with the ones from the boat *Puck 3*, it was possible to notice another significant feature that, unfortunately, sheds negative light on the reliability of the works carried out by O. Lienau. It occurred that the stem of the boat *Orunia III*, documented very well on raising (Lienau, 1934, fig. 23) has an entirely different shape than it was presented in his reconstruction drawing (Lienau, 1934, fig. 25). The stem is not so much round and, what is more, its curvature differs considerably from that suggested by Lienau, which is noticeable on the mentioned above photo. The question arises: why did

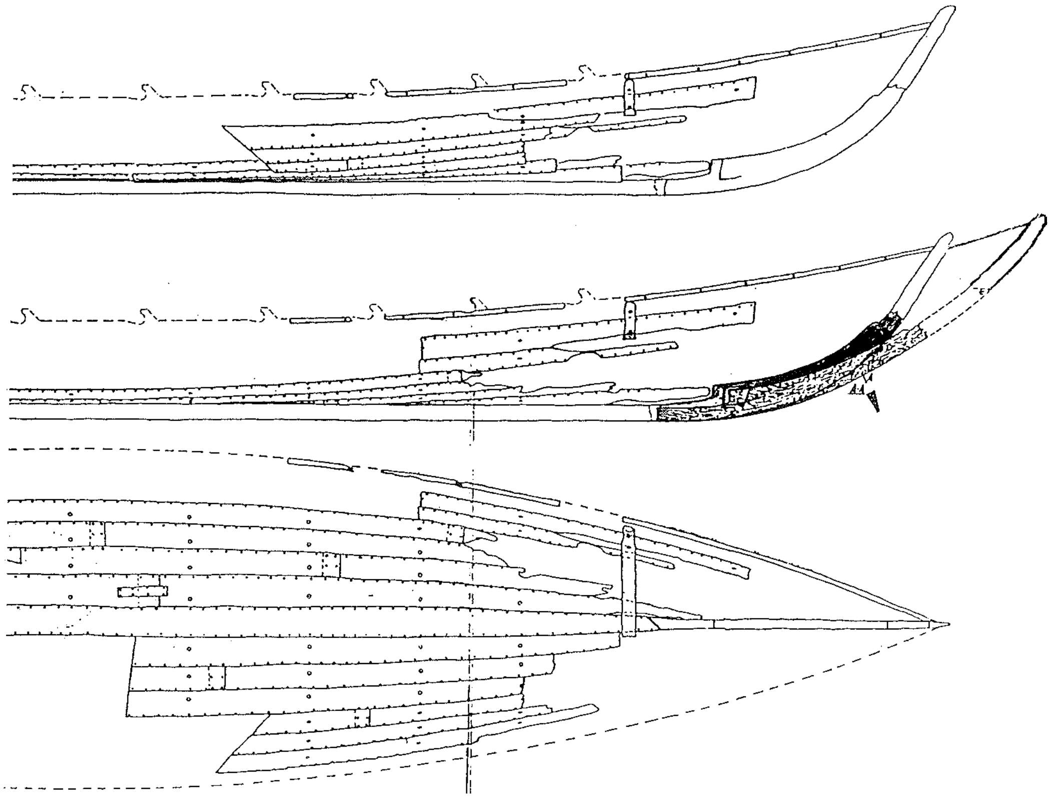

Fig. 39.6. The shape of the Orunia III *in the O. Lienau's reconstruction marked black and the stempost in the right shape makes new apperance of the former reconstruction.*

Lienau modify the appearance of the vessel to such a degree? Perhaps the stems, too bent and not round enough did not fit his ideas about the boat, reconstructed to some extent on the mode of the Viking craft (Fig. 39.6). However, if we assume a similarity between both these relicts, then we also must state that the sheathing with the stem was wrongly reconstructed, but how could Lienau not recognise the fact that there existed "connectors" – elements for the join of planks with the stem? For this reason, the boat *Orunia III* reconstruction, worked on by Lienau, is incorrect and distorted on purpose and, in this form, it should no longer be taken into account during scientific considerations. Instead, it is becoming necessary to work on the new reconstruction of the boat, with the usage of the linking connectors in mind, so a shape of the boat *Orunia III* should be corrected also. Coming with these short reflections to the end, I can say that the boats *Orunia III* and *Puck 3* represent the local boat-building technique. Moreover, the two craft might have been built in workshops with the same building method and, according to the datation, with the difference of approximately twenty years between each other. This productive environment did not generate the boat *Orunia II*, while *Orunia I*, similarly to *Orunia III* and *Puck 3*, probably represents an art of local boat-building, but nearly 50 years elder.

Acknowledgements

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40. The Szczecin Vessel – a 'Crossroad' of Shipbuilding Traditions or a Representative Artifact of Early Medieval Boatbuilding by Western Slavs?

George Indruszewski

Introduction

Remains of a planked vessel were unearthed during the archaeological excavations carried out in 1962 at the foothill of the Pomeranian Ducal Castle in the urban sector commonly-known as the *Fish Market*, the name being changed in the medieval times to the *Grocery Market* (Wachowiak, 1955; Wieczorowski, 1962).

Lying with its longitudinal axis parallel to the riverbed of the Oder River, the vessel was found immersed in a one-meter-thick layer of mud, which constituted also the lowest cultural level in one of the earliest-traceable urban structures at the Baltic seaboard (Wieczorowski, 1962: 179; Leciejewicz *et al.*, 1972, fig. 4b).[1]

The vessel was reconstructed by M. Jusza as a small craft with a length of 8.25 m and a breadth of 2.10 m, and his drawings were published and interpreted several times by W. Filipowiak (Filipowiak, 1985: 190, fig. 1; Filipowiak, 1988: 32, fig. 3; Filipowiak, 1994: 84, fig. 2). A layout of all frame-sections was published by M. Rulewicz in his attempt towards a full reconstruction and interpretation of the vessel (Rulewicz, 1996: 82, fig. 4). Its unique constructional features coupled with its dating, and its intra-site and inter-site location make this vessel a unique nautical object that found unjustifiably little attention among the nautical and other interest-related specialists. The following paragraphs, without even encompassing the entire subject, are suggestive of the informational thesaurus that lies behind this seemingly 'banal' craft poorly preserved and displayed in the exhibition hall of the National Museum in Szczecin.

Analysis of the vessel remains

The *keel-plank* was carved out carefully from a half oak-log; its main dimensions are 5.975 m in length, about 0.145 m moulded and 0.35 m sided (Wieczorowski, 1962: 181; Wesołowski, 1963: 255). It displays a specific U-shape profile with the uppermost sides extended in the horizontal plan so that it forms a contact surface for the garboard planks.

Special care was taken to ensure constant thickness in flanges (20 mm). The keel-plank changes its moulded[2] and sided[3] dimensions along a constant longitudinal dimension, which establishes not only the length of the keel, but also constitutes a kind of 'base-line' onto which the other dimensions vary in accordance with the builder's intention. This shows, among other things:

- the ability of the builder to perform a technological process that involves three-dimensional shaping;[4]
- that the cross-sectional shape, thickness of flanges, and length of keel-plank were basic choices made before the carving process started;
- the builder had previous knowledge related to hydrodynamics: the keel-plank attains its maximum dimensions exactly in the middle of its length.[5]

Both ends of the keel-plank were rabbeted on both sides, not for the lower ends of the garboards as one may presume, but for the seating of intermediary boards that can be interpreted as wings (Fig. 40.1).

Two important features are crucial in outlining the *assembly sequences*: the first is the forward end of the garboard in port and the second is the after end of the garboard in starboard.

The former represents the hooding end of the garboard at the joint with a wing: there is a short, about 4 cm-long scarf here cut into the outer side of the plank (Fig. 40.2). In contrast with this scarf, the after joint on the starboard side is represented by a scarf of similar length but cut into the inner side of the plank (Fig. 40.3). Both scarfs were secured by iron rivets with square shanks of about 6 mm in diameter. From the position of these scarfs, one can reconstruct the assembly sequence that started with the setting of wings in the aft, followed by the garboards and finally the wings forward. Dated to around 863 A D the Szczecin vessel represents thus, one of the earliest finds from Northern Europe showing, indirectly, the presence of rabbeted posts with wings (either one or both versions).[6]

Four strakes were preserved on either side of the keel. The planks averaged about 0.20–0.35 m in width and an average of 15 to 20 mm in thickness. The preserved strakes

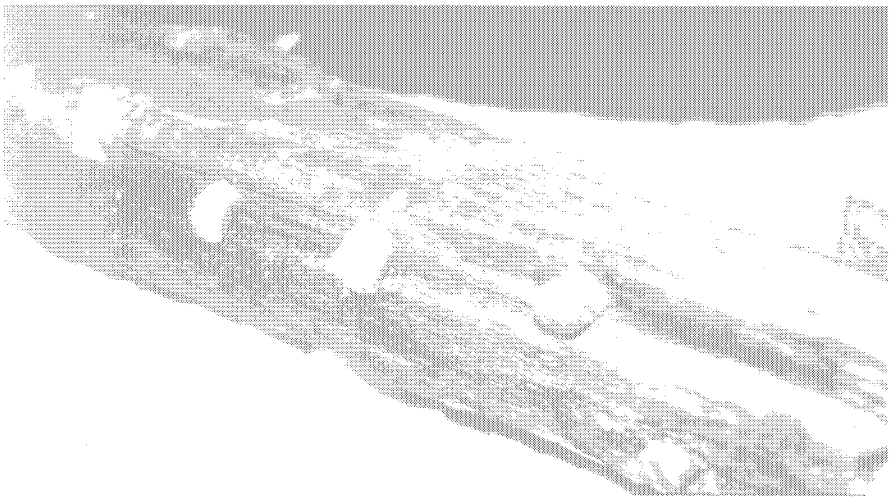

Fig. 40.1. Rabbet line at the keel-planks end on the starboard side (photo: author).

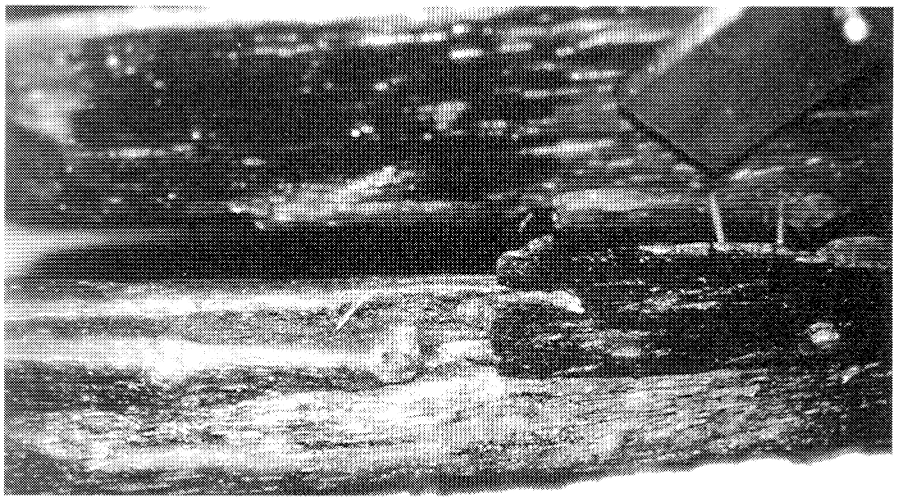

Fig. 40.2. Short scarf for wing joint on the outer face of the forward end of the garboard in port (photo: author).

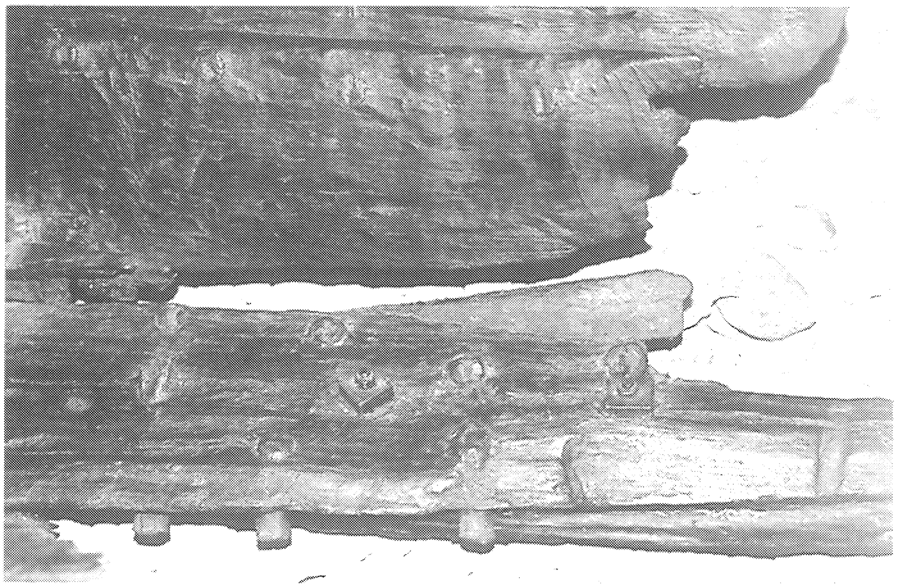

Fig. 40.3. Short scarf for wing joint on the inner face of the after end of the garboard in starboard (photo: author).

were made out of two overlapped planks with the scarf secured by two iron rivets driven at an approximately even distance from the plank sides and riveted from inside onto square roves.

The reconstruction of the *conversion technique of planking* shows that the Szczecin vessel was made entirely of radially-split oak, only the repair boards being tangentially-split. This shows that both cutting techniques were known and employed, and that the use of radial splitting for the ship planks was a deliberate choice.

Sampling for dendro-analysis provided the opportunity to record the cross-sectional shape of the *planks*. Plank thickness varies between 10 and 18 mm[7] and it seems that thickness increases upward, that is the thinnest plank is at the bottom and the thickest close or at the sheer strake. The cross-sections of planks show an interesting particularity: the roughly-rectangular shape is transformed by two features (one edge of each plank was beveled both on inside and outside so that the edge becomes curved with a flat contact surface corresponding to the landing between strakes); the other edge is also worked from both sides, the difference being that a cove was carved into the inner side for the luting material (Fig. 40.4).

Nevertheless, this feature seems to disappear imperceptibly from the bottom of the ship toward its uppermost planks. This reveals the unusual technical consideration given to the seams of the first two-three strake runs that makes the bottom of this vessel. Implicitly, it shows the degree of understanding of the role of a seam from a combined mechanical/watertight perspective.

The *analysis of scarfs* in the planking revealed that vertical, oblique scarfs were used to join planks in the strakes throughout the building process of the hull. Each scarf was secured by two iron rivets driven equidistant to the edges of the plank and between themselves. Two out of three pairs of preserved scarfs display a symmetrical location:[8] each scarf position has its analogy on the other side of the hull in about the same place (measured in the longitudinal plane of the vessel) and in the same analogue strake. This suggests that hull shaping was made apparently not only by 'eye-shaping' but also deductively. This, in turn, improves accuracy in the quest to build a symmetrical

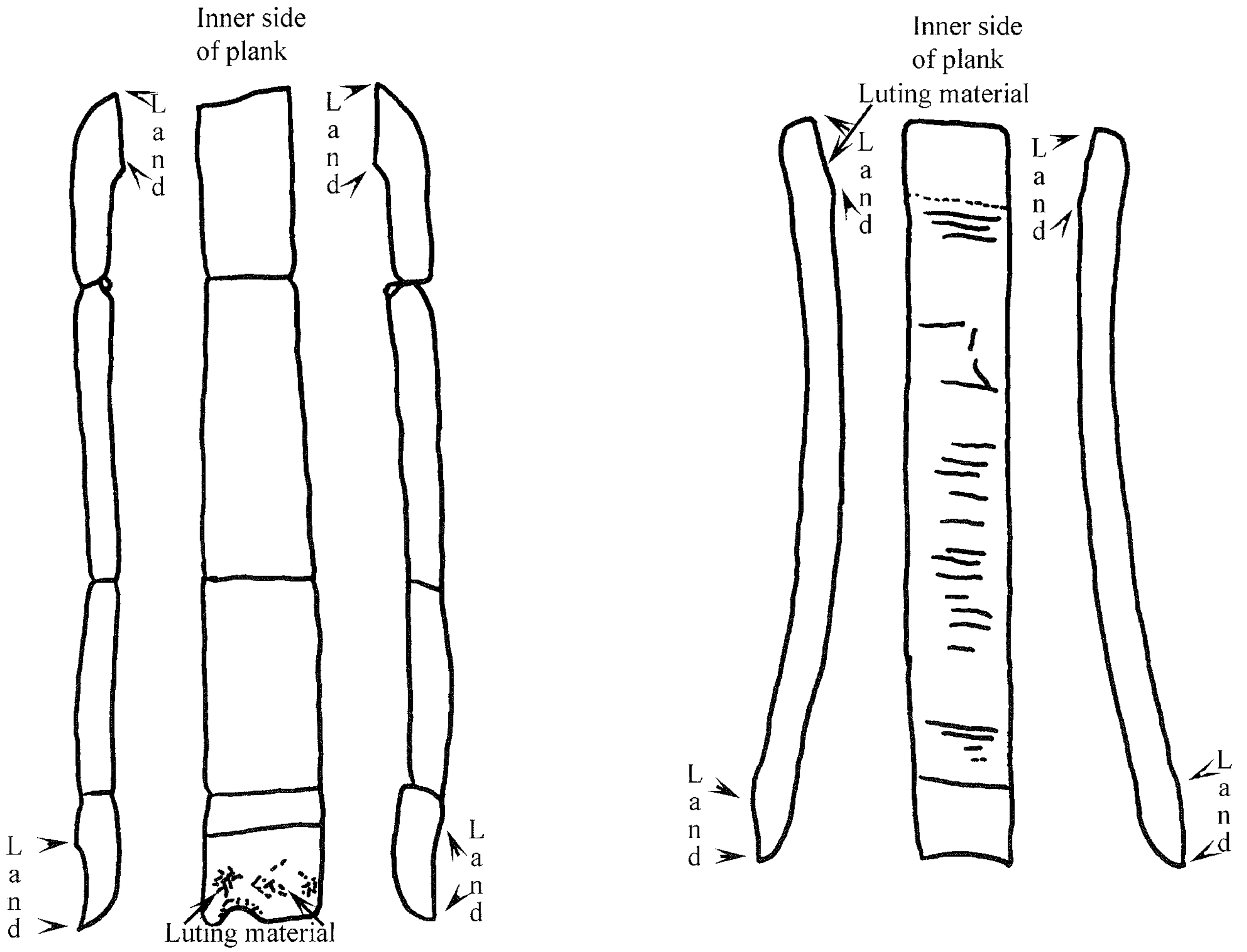

Fig. 40.4. Plank profiles of the second strake on both sides of the hull (drawing: G. Indruszewski, L. Thofte).

hull form. The care taken to build the bottom of this vessel is obvious at this point, but more informational ground is needed in order to check if the builder was familiar with and understood the principle of symmetry in hull shaping.

The luting material consisted of moss and mammal hair.[9] The microscopic analysis of moss samples[10] showed that underneath the aftermost repair plank moss of the *Scorpidium* family was laid; the moss was harvested, dried through compression, and laid onto the garboard plank in starboard. Mosses from the *Scorpidium* family are not particularly good to absorb water[11] hence its use under the repair board in the hull must have been dictated by other reasons than its sealing ability. Earlier analysis of luting materials used in seams of this vessel identified moss as belonging to the *Drepanocladus* sp. (Filipowiak, 1994: 93).[12] If this is the case, then two moss species were used in the same vessel in two different instances: *Drepanocladus* when building in/after 863 A D and *Scorpidium* in/ after 911 A D A string of twisted hair was inserted afterwards from outside the hull as caulking in order to improve watertightness. The hull was hauled onto the shore and turned up-side-down for this particular operation. This, together with other repair signs indicate the degree of 'care and management' this boat received during its active life. In addition, it illustrates the two basic techniques known and used for the same hull: luting and caulking.[13] What must be added here, is that the materials used for luting and caulking were impregnated with a substance resembling tar.[14] Treenails of about 15 mm in diameter were used as *fasteners* for the strakes of the Szczecin vessel; they were made of pine (*Pinus silvestris*), driven at about 9 cm-interval in the seams, and wedged from inside the hull with oak wedges (Fig. 40.5). This combination between pine and oak, shows the degree of empirical knowledge of physical properties of different tree species. Oak wedges were probably considered hard enough to secure the 'locking' of the treenail in place. As a general rule, treenails were carved with a distinct head that secured the treenail from 'slipping' inside the hole (Kruszewski, 1996: 24–25).[15] In some instances, the wedge was driven so deep that it split the head of the treenail, ensuring thus more internal pressure in the treenail. Here, we see again that both types of fasteners, treenails and iron rivets, were available locally, but the boatbuilders preferred to rely on treenails for seam fastening in planking boats and other craft.

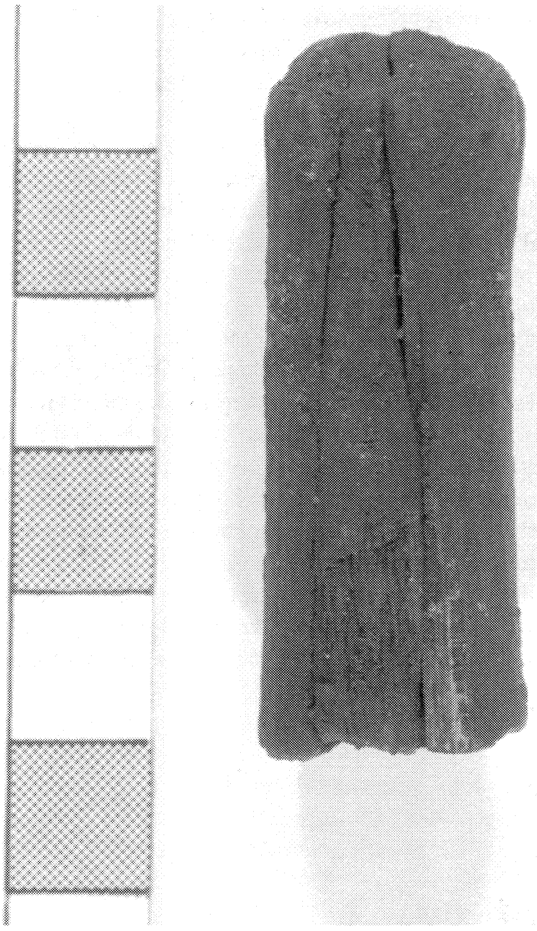

Fig. 40.5. Pine treenail split by an oak wedge (photo: W. Karrasch).

Conclusions

What can be said about the concept behind such a construction? The classic logboat remains as a used watercraft until modern times. Its concept is based on the principle of gravity, and this can be seen clearly in the recovered exemplars. Once the natural position of the log in the water is established, the builder tried throughout the conversion process to keep the center of gravity at the bottom of the craft (Moszyński, 1967: 682–683). This simple task has important consequences for the finished hull of the craft, and can be controlled by correlating thicknesses in the bottom area. The more balanced the hull, the better its seaworthy capabilities. This building-concept of balance, achieved by setting the vertical center of gravity (VCG) as close to the bottom as possible, was transferred to the extended/expanded logboat, and from there to the logboat-base. In these craft the combined effect of weight and shape (to a lesser extent in the case of the Oder mouth area material) of the bottom of the craft played a major role in balancing, especially for the craft exposed to rough waters in the Oder Lagoon or in the coastal area of the Pomeranian Bay.[16]

The second factor that conditioned seaworthiness in logboats was the size of the parent-log; the larger the log, the more robust the logboat would be. However, this 'run-for-size' seems to have been naturally limited by the availability of large trees. Related to the first issue aforementioned, the other factor that might have influenced the appearance of the planked-vessel was the quest to concentrate weight at the bottom of the craft. This was accomplished by letting more thickness in the bottom of the logboat-base,[17] and the logboat-base from Wolin site no. 10 is a good example in that direction.

This, however, was again limited by the size of the hull. The other solution was to set a keel-plank so heavy that it could give a fine balance in the craft. This was done in the case of the Szczecin vessel, where the keel-plank exhibits an unusual mass[18] as opposed to the thin planking and the light internal skeleton. The builder, thus, started to introduce gradually a new constructional solution that, nevertheless, was directed toward the accomplishment of the same task as set in the older conceptual thinking stemming from the classical logboat craft. On these grounds, the importance of the bottom part in these early craft cannot be underestimated.[19] The fact that the weight in the bottom played a major balancing role can be seen in thickness differences in the logboat-base in hulls of *drewel/kahn* type; in Rostock, for example, the logboat-base was thinned 50 mm more in the port than in the starboard side (Rudolph, 1966: 20). This was made to carefully balance the weight of the steering oar located in port.

Craft built on a logboat-base had also to be balanced in various ways: by letting more thickness in the middle of the base, by inserting frames thicker at their center, or by stringers/wales symmetrically placed on both sides.[20] This kind of concept could not afford a 'build-up' of the internal skeleton at the upper hull level, because that would move the vertical center of gravity (VCG) higher up in the hull. For this reason ribs and made-frames were seemingly the only alternatives. This is clearly seen in the Szczecin vessel where only two out of seven frames show a composite structure, and also in modern craft of the type *drewel/kahn/heuer*.[21] The keel-plank reiterates the balance-role. The floor-beam/thwart-knee has to be related to the other balance-concept introduced together with the T-shaped keel. The intermediate stage, that is the 'cutting into the flesh' of a Szczecin type keel-plank in order to obtain a T-shaped keel seems to point to:

1. abandonment of the older "balance-concept" in favor of a new one given by the shape of the hull;
2. change in the method of propulsion, reliance on sailing mostly;
3. increase in size of craft.

The major transition in conceptual thinking in boatbuilding was the transfer from the logboat concept to the multi-plank craft (Fig. 40.6). The log-boat itself is restrictive as regarding further development of its structure and form because it 'offers' the hull and the internal skeleton once and in the same time. The multi-plank vessel, on the other side, confers 'elasticity' to boatbuilding think-process as regarding hull shape, internal skeleton, and methods of hull assemblage.

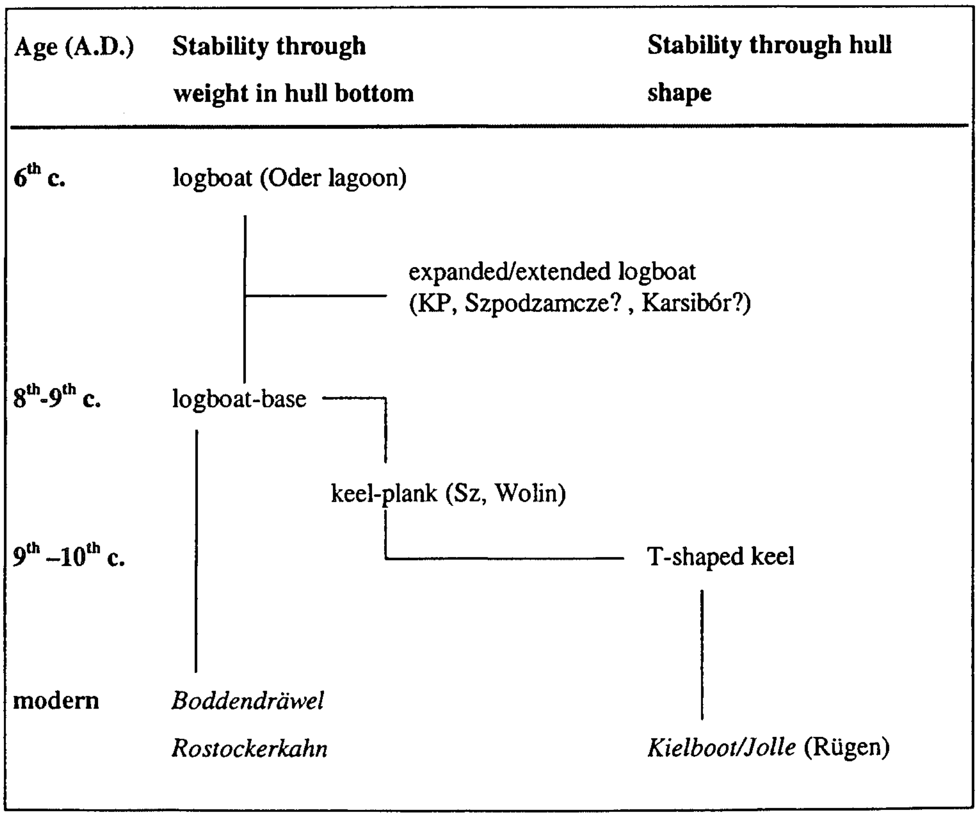

Fig. 40.6. Conceptual evolution of boatbuilding in the Oder mouth area.

With its massive-keel plank and its light structure reinforcing a planked hull, the Szczecin vessel represents a conceptual transition between the logboat and the sailing ship based on a T-shaped keel. In the same time, it can be viewed as a product that incorporates (modified) logboat traits and the planking vessel concept outlined by the Nydam boatfinds. From another point of view, it can be seen as a product where technical features of local origin fusion with traits considered general for the Baltic region.

Bearing in mind the estimated life expectancy in that period, the degree of know-how exhibited in the construction of the ships and boats, and the average productive time of the individual life, one should consider the building date for this vessel as 'trespass-able'. In other words, the technological achievement perceived in the Szczecin vessel corresponded to the societal needs of the inhabitants of Szczecin, and as such it represents not the first step but the next sequential step in the development of a local shipbuilding tradition. Therefore, one cannot take the date of 863 A D as *the date* when the shipbuilding of planking boats started in the area. Based on this developmental sequence, the technological knowledge must have been the result of a gradual 'build-up' that can be easily pushed back into at least the 8th cent. A D. This statement can be grounded also by the fact that the builder made several technological choices along the entire constructional process. The fact that he had chosen indicates that he had also the knowledge to do so.

On this basis, it can be inferred that a conceptual diffusion across ethnic borders could have been taken place in the form of a formal stylistic congruence at a time when boatbuilding in the Oder mouth area was already on a developmental path that produced vessels of a similar type to the so-called *Rostockerkahn*. This kind of craft was nothing but a last (and lasting) developmental link from the simple logboat type. While this craft continued its existence until recent times in a more-or-less unchanged form, its further development was incorporated in the kind of vessel seen in Szczecin.

Notes

[1] According to Wesołowski, the layer, classified as layer no. 33, was dated after the artifact assemblage to the end of the 8th cent. A D. The stratigraphic sequence was published later by Leciejewicz *et al.*, eds., 1972.

[2] The height of the keel changes from aft at 4 A (100 mm) to midship area at 1 F (145–150 mm) and then to the forward end at 3 F (120 mm).

[3] The width of the keel (the sided dimension of the vertical component excluding flange widths) changes from aft at 4 A (100 mm) to midship area at 1 F (240 mm), and then to forward end at 3 F (100 mm).

[4] Derived from the Greek *tekhnologia*, meaning a systemic reasoning used in a craft or art (the word *tekhnê* = skill and *–logia* = a mode of reasoning), the process of obtaining a precisely-delineated product is in this period mostly a result of empirical reasoning.

[5] The placement of weight at this point influences: the position of LCG and implicitly of LCB, the trim of the vessel, and the maneuverability of the double-ended hull.

[6] The earliest find with wings of both variants is the large ship from Gokstad, Norway dated to 895–900 A D.

[7] Adding 10% thickness loss due to shrinkage the original values can be read as 11–20 mm.

[8] Only the scarfs in the second strake on both port and starboard sides seem to have been skewed.

[9] The samples were checked by C. Malmros (29th of January 1998) and D. E. Robinson (25th of June 1998), both from NNU Department at the National Museum in Copenhagen, Denmark. Their results have been confronted in order to describe more accurately the watertight materials used in the Szczecin vessel.

[10] The analysis has been carried out by G.S. Mogensen, at the Botanical Museum in Copenhagen, Denmark. The moss seems to have been fully-grown at the harvest time. It displays very narrow leaves that were osmotically compressed/squeezed. This may indicate that the moss was dried before usage as ship-watertight material. The moss seems to be from the *Scorpidium* sp. with symmetrical leaves. It is known in the Baltic region as well as Northwestern Europe.

[11] This type prefers calcareous areas, soils with a high ph degree. Its area of distribution is wide: from the temperate to the arctic zone. It is a wet-moss that lives in water only, mostly in mires, and lakes with little water movement. It is a big-leaf plant, counted as a giant among the moss species. It grows at the bottom of lakes, up to 0.6–0.7 m in length, and its water-absorbing capacity is low.

[12] Analysis carried by M. Jasnowski and E. Fudali from the Academy of Agronomy in Szczecin, Poland.

[13] The difference between the two resides in the method of obtaining watertightness: luting presuposes that the material is laid *before* the planks are assembled in the hull, while caulking is seen mostly as the insertion of material in an already existing structure (hull, deck, etc.).

[14] While no particular analysis was performed on the impregnating substance, the chemical cleaning of luting material succeeded to dissolve the impregnated substance in a kind of oily, dark-brown, and viscous liquid that resembles tar. The solvent solution was recommended by researchers from the National Museums Conservation Department in Brede, Denmark, after the first attempt to dissolve the substance with gasoline proved unsuccessful. Here, it should be added that in some samples, 'golden crystals' were found in the luting cove, the substance not being identified at the moment.

[15] While this feature is difficult to be observed in archaeological finds, it is nonetheless present, most often in the form of slightly flared sides that stop into a well-defined edge-end carved *across* the longitudinal grain of the wood. The way of carving determines the final appearance of the treenail. The mechanical role played by the diameter of the head in relationship to that of the shaft is crucial in locking the treenail in place.

[16] The logboat from Czołpino and that from the Gotland Deep are two eloquent examples of logboats used at sea. Their provenience and area of usage raises though difficulties. On one hand, there is a typological agreement between the Gotland Deep logboat and the Slusegård logboat material (Crumlin-Pedersen, 1970: 231–233), while on the other, its provenience – as indicated by dendrochronological analysis – seems to be on the Southern Baltic shores (Pomerania and Mecklenburg-Vorpommern) (Krąpiec, 1999: 255). In addition, such a logboat could have well been adrift from a river mouth to the place of sinking (Crumlin-Pedersen, 1995: 242). The apparent contradiction between these factors seems rather to reinforce the

possibility of crossing (or crossing attempts) the Baltic in logboat-type craft.

[17] The Kashubian fishing logboats from the beginning of the 20th century had a bottom thickness of up to 15–20 cm for increased stability (Moszyński, 1967: 683).

[18] The comparison with other keeled vessels makes more perceivable the mass difference between these and the Szczecin keelplank. For details see Crumlin-Pedersen, 1997: 112, fig. 5.6.

[19] J. Litwin stated that the bottom of the logboat did not play a major role, hence it was gradually transformed into a keel (Litwin, 1992: 351).

[20] A perfect example is offered by the *Utrecht* vessel, which has two half-logs just above the garboard strakes on both sides of the 6 cm thin logboat-base. Outer 'stabilizers' were also documented in modern logboats from Poland, Finland/Russia (Carelia), Sweden (Norra Småland), and in the 14th century craft from Kentmere, England (Wilson, 1966). A reminiscence of this kind of balance concept might be seen in the *meginhufr* present in large cargo traders from the Viking Age such as *Klåstad, Skuldelev 1, Hedeby 1*, etc., interpreted as a descendent of the thicker sheer strake seen in the *Nydam* oak ship.

[21] These craft exhibit a fourth type of internal structure, that is the bulkheads. These have direct correspondents in logboats.

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41. Large Cargo Vessels in Danish Waters 1000–1250. Archaeological Evidence for Professional Merchant Seafaring before the Hanseatic Period

Anton Englert

Introduction

There are few written sources on merchant seafaring in medieval Denmark before the 13th century. However, historians generally agree on the existence of a Scandinavian system of long distance trade connecting the West and East of Northern Europe at Hedeby/Schleswig and Gotland from the 10th to the 13th century, followed by a long period of professional merchant seafaring dominated by German/Hanseatic merchants (Christensen, 1957; 1966; Hoffmann, 1989; Bill *et al.*, 1997).

There remains the question, how professional pre-Hanseatic Danish merchant seafaring was. Professional merchant seafaring may here be understood as a regular, profitable and integrated engagement in large-scale goods exchange in opposition to limited surplus trade of mainly self-sufficient agricultural estates. Each of the following aspects may be considered as an indicator for professional merchant seafaring:

1. Free merchants living from their trade rather than from their land.
2. Multiple ownership of ships or their cargo and the codification of maritime law.
3. Towns with access to navigable waters.
4. Genuine sailing vessels and large cargo vessels in particular.

1. To distinguish the professional merchant from a trading landowner, a merchant should be considered a professional merchant, if his economy is more based on his commercial gains than on his or his family's rural household or on any service relationship to a magnate or king.

For the lack of accounting documents it is difficult to investigate the economy of single Viking Age and high medieval merchants and to prove the existence of professional merchants by this definition. Neither do archaeology and numismatics reveal the income situation of single merchants. Even in rich Viking Age-burials, it is difficult to even identify merchants, as possible indicators like imported goods or trade-related objects like scales and weights can be attributed to a travelling merchant as well as to a local customer (Steuer, 1987: 119).

2. Because of its co-operative and profitable character, multiple ownership of ships or their cargoes may be considered as an early feature of professional merchant seafaring. Commercial co-operation between freemen results in binding rules. Codification of maritime law may be seen as a further degree of professionalism.

Unfortunately there is only little written evidence for multiple ownership of cargo ships and cargo and co-operative merchant seafaring in Denmark for the time before 1170. The oldest known codification of maritime law in Denmark followed in the first half of the 13th century (Ventegodt, 1982: 52; Müller-Boysen, 1990: 130–152).

3. Throughout the period 1000 to 1250, the majority of Danish urban settlements were accessible for water transport. Professional merchant seafaring may have been triggered by the breakthrough of a money-based economy and the increased commercial and central function of the existing towns after 1130. From 1200 to 1250, fjord and inlet locations accessible by seagoing vessels seem to have provided a major criterion for the rise of new towns (Bill, 1993: 40). It may be assumed that professional seafaring rose in quantity according to the growing number of harbour towns and the increase of agrarian surplus production.

4. Another indicator for professional merchant seafaring can be seen in the use of purpose-built cargo vessels. Purpose-built cargo vessels are represented by the finds of genuine sailing vessels, ships depending on the wind for propulsion. The main advantage of genuine sailing vessels compared to combined rowing and sailing ships can be seen in their cargo capacity and their seaworthiness, both of which improve with the size of the vessels. Large cargo vessels are expensive to build and operate, but if they are rationally used, their large cargo capacity can be a very profitable source of income for the owners. Large cargo vessels can therefore be claimed to be sophisticated

tools of commerce and consequently, valuable indicators of professional merchant seafaring. One cannot exclude that genuine sailing ships were used for military operations as well, but due to their limited manoeuvrability and their dependence on the wind, they would only have been suitable for the massive deployment of power and not for small scale hit and run warfare. The deliberate hostile use of cargo vessels in Denmark between 1000 and 1200 is here only mentioned as a theoretical possibility. The Danish sources are silent on this aspect. The early Danish historian Saxo Grammaticus, for instance, often mentions combined rowing and sailing ships, but no genuine sailing vessels for the use in warfare.

The evaluation of the first three indicators of professional merchant seafaring is partly biased by limited written sources, whereas ship-finds cover the whole period of investigation. They can be absolutely dated by the means of dendrochronology and they may yield evidence of their origin, cargo capacity and other characteristics. Therefore this paper focuses on the significance of and evidence for large cargo vessels in Danish waters before 1250.

The advent of the genuine sailing vessel

At some time in the last part of the 10th century, a differentiation of ship types took place within the Nordic shipbuilding tradition. Beside combined rowing and sailing personnel carriers, genuine sailing vessels were introduced. The wide frame spacing needed for an optimal distance between the oarsmen was abandoned in favour of a stronger hull. A spacious cargo hold was created in the middle of the ship without thwarts for oarsmen and without deck beams and deck. Only near the mast and at both ends of the hold, heavy beams supported the sides of the ship. Adjacent to the hold, fully decked working platforms were built – an after and a fore deck. Stronger and therefore heavier timbers were chosen. Crumlin-Pedersen (1999: fig. 5) has demonstrated the development of the different ship types by comparing the beam/length ratio of several well documented ship-finds of the period AD 300–1200 (Fig. 41.1).

The differentiation in hull shape, size and function is most obvious in the unique 11th century find complex of Skuldelev, where two cargo ships and two personnel carriers of very different size and origin were scuttled at the same site in order to block one of the fairways leading to Roskilde (Olsen, Crumlin-Pedersen, 1968, Crumlin-Pedersen, in press). The first known purpose-built cargo vessels from Scandinavia are the Klåstad ship on the south-east coast of Norway, built after *ca.* AD 990 (Christensen, Leiro, 1976; Hylleberg Eriksen, 1993) and the *Äskekärr 1* ship, found at the Göta river and built locally *ca.* AD 1000. Already a quarter of a century later, *ca.* 1025, *Hedeby 3*, one of the largest Nordic cargo ships was built locally with an estimated cargo capacity of 60 metric tons (Crumlin-Pedersen, 1997: 99–104). The impression that the Nordic cargo ships suddenly emerged in full size may be due to the low number of recorded ship-finds of the centuries before the year 1000.

Large and medium sized cargo vessels in Danish waters 1000–1250

In order to study the evidence of large cargo vessels, a comparative analysis was made of all tree-ring dated finds of cargo vessels of over 14.5 m reconstructed length which have been found in present Denmark, the Swedish provinces of Halland, Scania, Blekinge and the German part of the former duchy of Schleswig (Table 41.1; Fig. 41.2).

The minimum size of 14.5 m was chosen to exclude smaller vessels like the *Skuldelev 3* ship of ca. 14 m length with its comparatively low cargo capacity of only 4.6 tons (Crumlin-Pedersen, 1999: 12; Jensen, 1999: B 30–31). Because of its find location at the Göta river, in the ancient border zone between the kingdoms of Norway, Sweden and Denmark, the Swedish *Äskekärr 1* find has been included.

The cargo capacities of the ship-finds *Skuldelev 1*, *Lynæs 1*, *Ellingå* and *Kollerup* have been recalculated by the author (Englert, 2000). The capacities of the newly

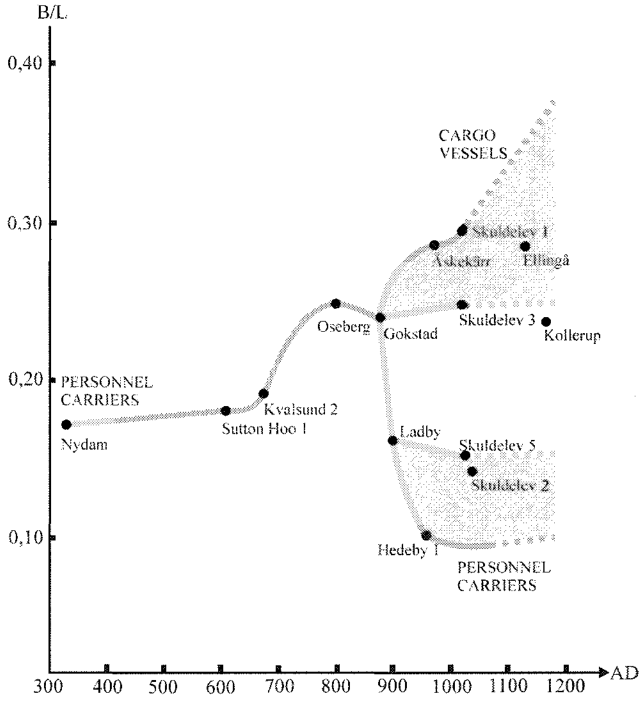

Fig. 41.1. The beam/length ratio of well documented northern European ship-finds over 14 m length AD 300-1200 displays a differentiation into spacious cargo vessels exclusively propelled by sail (genuine sailing vessels) and slender and fast personnel carriers propelled by oars and sails. After Crumlin-Pedersen (1999: Fig. 5).

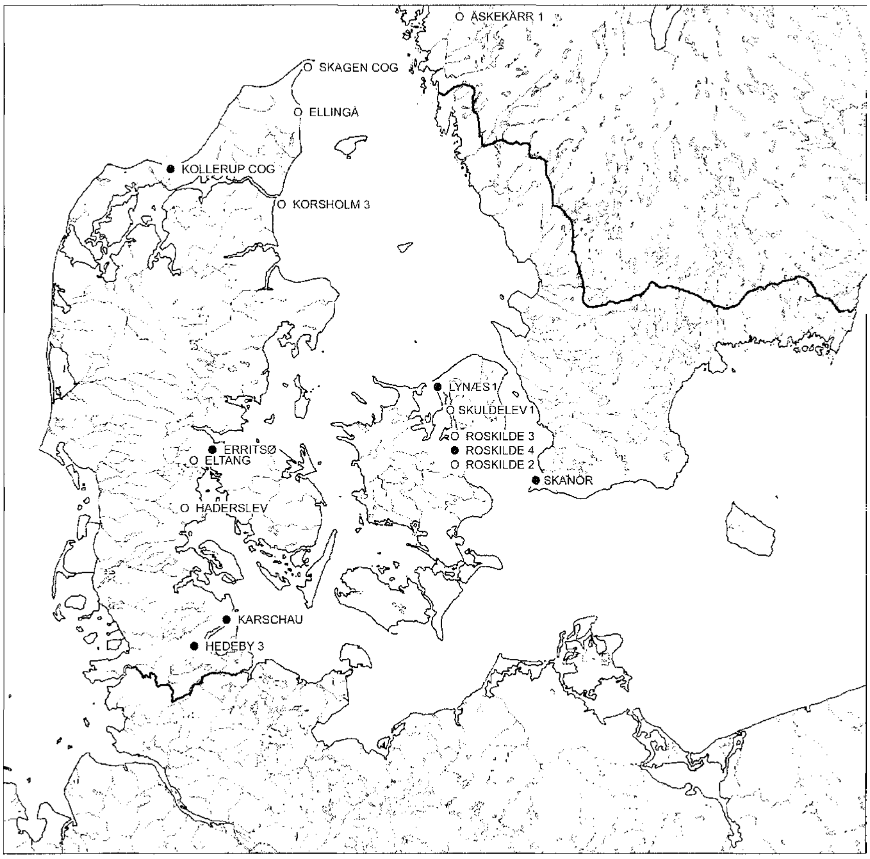

Fig. 41.2. Find distribution of large cargo ship-finds over 14.5 m reconstructed length in medieval Danish waters 1000-250. Large cargo vessels are marked with black dots.

No.	Ship-find	Felling date	Timber provenance	Length (m)	Beam (m)	Ratio L/B	Draught (m)	Displ. (t)	Cargo capacity (t)
L 01	Äskekärr 1	ca. 1000	Southwest Sweden	ca. 15.8	ca. 4.5	3.5	ca. 1.17	ca. 29	ca. 20.
L 06	Hedeby 3	ca. 1025	Schleswig-Holstein	ca. 22.1	ca. 6.25	3.5	ca. 1.50	ca. 75	ca. 60.
L 16	Skuldelev 1	1030/1045	Western Norway	ca. 16.0	ca. 4.84	3.3	ca. 1.28	ca. 36	ca. 27.5
L 12	Roskilde 3	1055/1065	Jutland/Schl.-Holstein	ca. 18.0	ca. 4.4	4.1	ca. 1.0		ca. 11.
L 13	Roskilde 4	1108/1113	–	ca. 20.5	ca. 6.4	3.2	ca. 1.5		50–60
L 07	Karschau	ca. 1130+	West Baltic region	22–25	o. 6.4				50–60
L 10	Lynæs 1	ca. 1140	Southwest Sweden	ca. 25.	ca. 6.5	3.8	ca. 1.51	ca. 75	ca. 57.
L 03	Eltang	ca. 1140	Jutland/Schl.-Holstein	ca. 17.5	–				
L 15	Skanör	1148/1153	–	ca. 20.	–				
L 08	Kollerup cog	ca. 1150	South Jutland	ca. 20.9	ca. 4.92	4.2	ca. 1.35	ca. 65	ca. 42.
L 02	Ellingå	1163	–	ca. 14.5	ca. 4.18	3.5	ca. 1.07	ca. 20	ca. 13.5
L 04	Erritsø	ca. 1180	–	ca. 20.	o. 4.2				
L 11	Roskilde 2	ca. 1185	Southwest Sweden	ca. 16.5	ca. 4.5	3.7	ca 1.1		ca. 15.
L 14	Skagen cog	ca. 1193	–	ov.17.5	o. 4.0				
L 09	Korsholm 3	1201/1207	–	15–20	–				
L 05	Haderslev	ca. 1220	Jutl./Funen/Schl.-Holst.	12–21	ca. 5.0	?	o. 0.9	14–65	

Table 41.1. Dimensions and cargo capacities of cargo vessels over 14.5 m reconstructed length found on the coasts of medieval Denmark 1000-1250. All displacements refer to a draught of 60% of the midship height. The cargo capacities of the ship-finds from Hedeby, Roskilde and Karschau are only estimated.

Reference key to the ship-finds: *L 1 Äskekärr 1*: Humbla, 1934; Borg *et al.*, 2000. Dating: Bråthen, 1998; O. Crumlin-Pedersen pers. comm. *L 2 Ellingå*: Laursen, 1971; Crumlin-Pedersen, 1992; Jensen, 1999: B42–43. Dating: Bonde *et al.*, 1991: 234–235. *L 3 Eltang*: Skov, 1952;Crumlin-Pedersen, 1981:39; fig. 7. Dating: Bonde, Daly, 2000: 331–332. *L 4 Erritsø*: Ussing, 1929; Bill, 1997: 165, fig. 72. Dating: Bonde, Daly, 1998: 295. *L 5 Haderslev*: Neumann, 1957; Englert, 2000. Dating: Daly, 2000a. *L 6 Hedeby 3*: Crumlin-Pedersen, 1997: 99–104; 242–251; Jensen, 1999: B42–43. *L 7 Karschau*: Englert *et al.*, 2000. *L 8 Kollerup cog*: Kohrtz Andersen, 1983; Jensen, 1999: B44–45. Dating: Daly, 2000b. *L 9 Korsholm 3*: Bill, 1995: 199, fig. 10; Bill, 1997: 179–180. Dating: Bonde, Daly, 1998: 297–298. *L 10 Lynæs 1*: Crumlin-Pedersen, 1979; Englert, 2000. Dating: Bonde, Daly, 2000: 331. *L 11, 12, 13 Roskilde 2, 3, 4*: Myrhøj, Gøthche, 1997; Bill *et al.*, 2000: Dating: Bonde, Daly, 1998: 298; Bonde, Daly, 1999: 351–352; Bonde, Daly, 2000. *L 14 Skagen cog*: Lønstrup, Nielsen, 1997: 24–25; Bill, 1997: 192–193, fig. 72. Dating: Bonde, 1995: 302. *L 15 Skanör* (Knösen): Hörberg, 1995: 123–125; Fransson, Robert, 1997. *L 16 Skuldelev 1*: Olsen, Crumlin-Pedersen, 1968; Jensen, 1999: B28–29; Crumlin-Pedersen, in press. Dating: Bartholin, 1998.

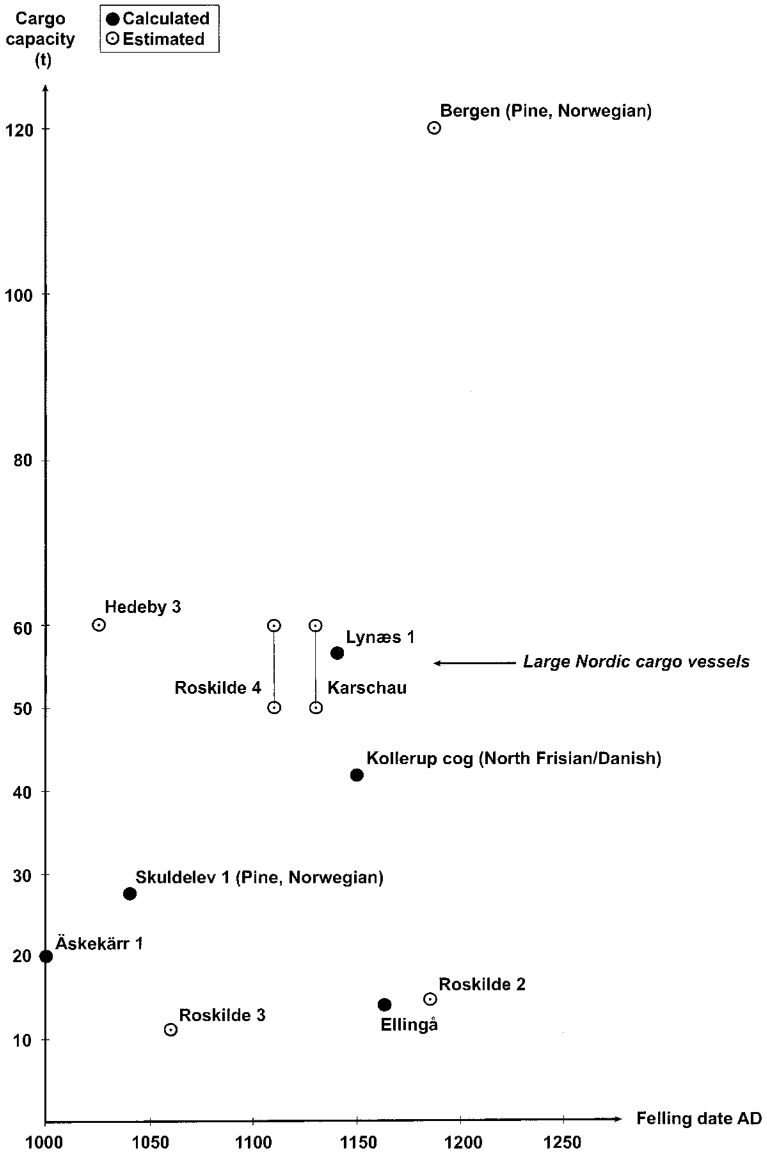

Fig. 41.3. Cargo capacities of cargo ships over 14.5 m reconstructed length from medieval Danish waters 1000-1250. For better comparison, the Bergen ship has been included.

excavated *Roskilde* ships *2, 3* and *4* have been preliminarily estimated by M. Gøthche (Bill *et al.*, 1998). The capacity of the *Karschau* ship is roughly estimated to 50 to 60 tons because of its similarity with the *Lynæs 1* ship. The cargo capacity of six ship-finds, *Erritsø, Eltang, Skanör, Skagen, Korsholm 3* and *Haderslev* could neither be calculated nor sufficiently estimated. The displacement and length data from Table 41.1 are here presented in diagrams for easier reading (Figs. 41.3–41.4). For better comparison, the Big Ship from Bergen, recently tree-ring-dated to 1188, has been included (Christensen, 1985; Bartholin, Englert, 2000).

Both diagrams allow a first distinction into a group of large cargo vessels of over 40 tons cargo capacity and over 20 m length and a group of medium-sized cargo vessels of 10–40 tons ranging between 14 and 20 m length. A closer look reveals that the oak ships of Nordic clinker construction *Hedeby 3, Roskilde 4, Karschau* and *Lynæs* belong to a rather homogenous size class of 50–60 tons cargo capacity and 20–25 m length throughout a building period of *ca.* 115 years from *ca.* 1025–1140. The *Erritsø* and *Skanör* ships would enlarge this large cargo group to six oak-built ships until *ca.* 1180. The dating of the *Korsholm 3* wreck with its typological resemblance to the *Lynæs* and *Karschau* ships suggests that this group may have been built during almost 200 years until *ca.* 1205.

The *Skuldelev 1* ship as well as the *Bergen* ship have to be seen in a different light. They are built of a different material in a different geographical and economic environment in Western Norway. One should not unconsciously mix their evidence with the other Nordic ships in the diagrams which were built in oak and which most likely

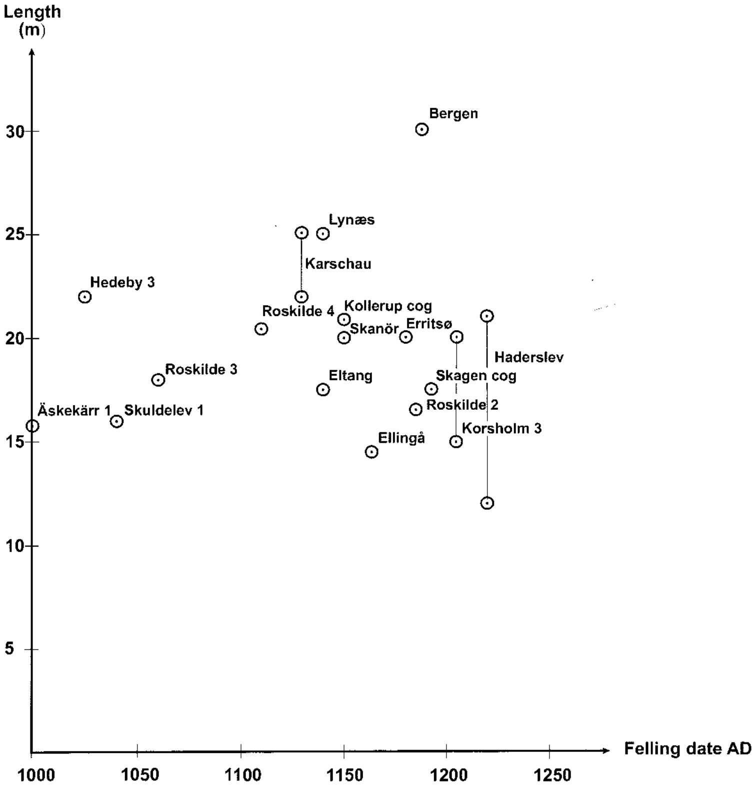

Fig. 41.4. The reconstructed length of cargo ships over 14.5 m from medieval Danish waters 1000–1250. For better comparison, the Bergen ship has been included.

originate from medieval Danish territory. It is possible that ships of similar shape and size like the *Skuldelev 1* and *Bergen* ship were built in medieval Denmark but it is not proved.

The *Kollerup* cog joins the large cargo group *ca.* 1150, representing a completely different building tradition within the same area, probably deriving from North Frisian influence on the west coast of Jutland. The *Kollerup* cog and the *Skagen* cog of ca 17.5 m length suggest that the seagoing cogs of the 12th century might have been slightly smaller in size and cargo capacity than the large Nordic cargo vessels. Of course, this idea needs to be confirmed by more finds.

A small group of four ships, *Äskekärr 1, Roskilde 3, Ellingå* and *Roskilde 2* represent a medium-sized group from the medieval Danish coasts of 10–20 tons cargo capacity and 14–18 m length. Below this group range the ships which Crumlin-Pedersen calls "small coastal vessels of up to 10 tons", like the *Skuldelev 3* ship of 14 m length but only 5 tons cargo capacity. The *Korsholm 3* wreck and the *Haderslev* wreck cannot firmly be associated to one of the size groups because of their rudimentary preservation.

The reconstructed large cargo vessels do not exceed a draught of *ca.* 1.5 m, whereas the *Kollerup* cog despite its sturdy construction and a similar length can slip through even shallower waters with a calculated draught of only 1.35 m. The medium-sized cargo vessels of probable medieval Danish origin draw 1.0–1.2 m. It appears that none of the cargo vessels drew much more than 1.5 m. This observation suggests that the shipbuilders had no specific concept of increasing the height of the vessels in order to gain more cargo capacity. They rather increased the dimensions in general. This behaviour may partly derive from a traditional quasi-organic boat building concept but was probably also determined by the intention to be able to sail and land in a variety of locations on the coasts of medieval Denmark.

In Table 41.2 the results of the size analysis are compared to the classification by Crumlin-Pedersen in 1998 (Crumlin-Pedersen, 1999: 18).

In general, the conclusions drawn by Crumlin-Pedersen could be confirmed. In addition, the *Kollerup* cog may be considered a vessel belonging to the largest class of seagoing cargo vessels in Denmark at the time, in spite of its strange appearance.

The great gap in size between the "Danish" large cargo vessels and the "Danish" medium-sized cargo vessels can be caused by the following factors:

- The small and still unrepresentative number of finds giving a wrong impression.
- Different functions leading to different vessel sizes.
- Different social and economic positions of the respective owners leading to different vessel sizes.

Crumlin-Pedersen 1998

Cargo vessels of Nordic origin AD 1000-1140	**Cargo capacity**
Deep-sea cargo carriers:	50-60 t
Medium-sized vessels:	10-25 t
Small coastal vessels:	< 10 t

Englert 2000

Cargo vessels built in Denmark AD 1000-1205	**Cargo capacity**	**Length**	**Draught**
Large cargo vessels of Nordic tradition:	50-60 t	20-25 m	ca. 1.5 m
Large cargo vessels of Cog tradition (after ca. 1150):	42 t (Kollerup)	21 m (Kollerup)	ca. 1.35 m
Medium-sized cargo vessels:	10-20 t	14-18 m	1.0-1.2 m
Small cargo vessels:	< 10 t	< 14 m	< 1.0 m

Table 41.2. Comparison between the classification by Crumlin-Pedersen (1999: 18) and the author.

A class of large cargo vessels

The finds of large cargo vessels distinguish themselves from other cargo ship finds by three features:

1. The large cargo vessels had a much larger capacity than other vessels.
2. Only large cargo vessels were found wrecked outside natural harbours or on the open coast.
3. Almost all large cargo ships which where not lost en route, were found within reach of prominent Danish ports, namely Roskilde and Schleswig.

It has to be pointed out that the identified large cargo vessels are only seven ships of a total of 16 finds from a period of 250 years. Therefore, only preliminary conclusions can be drawn in the following:

1. If the gap in size between the large cargo vessels and the medium-sized cargo vessels is not caused by the small and hardly representative number of finds, an explanation for the different vessel sizes may either be found in different vessel functions or in different social and economic positions of the respective owners.
2. The fact that only large cargo vessels were found wrecked outside natural harbours suggests a tendency for large cargo vessels to be used on such a regular basis that they were exposed to the danger of shipwreck outside natural harbours after *ca.* 1130. The medium-sized vessel finds were possibly used in greater accordance to the weather situation and may have been beached in critical situations.
3. The find distribution of large cargo vessels points towards a direct relationship between the large cargo ships and major ports and centres of secular and ecclesiastical power and trade.

These preliminary conclusions from the archaeological evidence suggest that the examined large cargo vessels were expensive craft connected to major ports and seats of power and trade, used on a regular basis after 1130 at the latest. Considering the considerable resources needed for the building and equipping of large cargo ships, one may assume that these vessels were used for professional trade, primarily with bulk cargo, and that they were owned by rich merchants or by important members of the nobility or the clergy. Apart from the medium-sized *Skuldelev 1* ship from western Norway, the examined ships fail to prove any long distance contacts.

Conclusions

Finally, the evidence of genuine sailing vessels can be listed together with the earlier discussed indicators for professional merchant seafaring in Denmark from 1000 to 1250, before merchants from German ports started dominating large-scale trade (Table 41.3).

The direct comparison shows that the evidence for professional merchant seafaring in medieval Denmark grows step by step before reaching a point of full coverage towards 1200. The number of towns increases continuously by three to four towns per half century until 1200, followed by a sudden rise from 19 to 47 towns within the 50 years from 1200 to 1250, with three quarters of them having access to navigable waters (Andrén, 1985; Bill, 1993). The consolidation of royal power and administration at the end of the Viking Age is represented by the specific taxation of towns and by the enforcement of a monetary standard based on the face value of the coins. The lack of *written evidence* of free merchants and the operation of merchant ships before the second half of the 12th century probably derive from low contemporary standards of literacy and archive keeping.

In contrast to the sparse historical evidence, the *archaeological finds* of genuine sailing vessels provide some of the oldest evidence for professional merchant seafaring in Denmark. According to the nature of archaeological remains, they are hardly representative in a statistical sense but in their existence and size. The first archaeological appearance of genuine sailing vessels falls in the period after the consolidation of central royal power in Denmark in the late 10th century. It is remarkable that already the

Evidence for professional merchant seafaring	*Evid.*	*1000-1050*	*1050-1100*	*1100-1150*	*1150-1200*	*1200-1250*
Free merchants living of their trade	W	?	?	?	x	x
Co-operative merchant seafaring	W	?	?	?	x	x
Multiple ownership of ships/cargo	W	x	?	?	x	x
Codification of maritime law	W	-	-	-	?	x
Money-based economy	A/W	-	x	x	x	x
Specific taxation of towns	W	-	x	x	x	x
Towns with navigable waters/all towns at the end of each period	A/W	6/10 (60%)	9/14 (64%)	11/17 (65%)	12/19 (63%)	36/47 (77%)
Finds of genuine sailing vessels of over 14.5 m length	A	3	1	4	6	2
Finds of large cargo vessels 40-60 t	A	1	-	3	4	1?
Ships lost outside natural harbours	A	-	-	3	5	-

Table 41.3. Comparative status of evidence for professional merchant seafaring in medieval Denmark AD 1000–1250. W: Written evidence; A: Archaeological evidence. Town data after Andrén (1985) & Bill (1993).

second oldest Nordic cargo ship-find from the waters of medieval Denmark, *Hedeby 3*, built around 1025, belonged to the class of large Nordic cargo ships of 50–60 tons cargo capacity. The fact that the specific features of Nordic shipbuilding like the *biti*-system disappeared around 1200 has been explained by J. Bill (1997) as a transition from a traditional regional concept to a more functional and common northern European design. The absence of an accepted central power might have hindered the development of professional merchant seafaring and cargo vessels in other Baltic Sea regions. This may be a possible explanation why there are yet no finds of large cargo vessels of Slavic origin (Crumlin-Pedersen, 1999: 18).

The evidence for large cargo vessels in Danish waters 1000–1250 indicates that large cargo vessels were built and operated professionally in Denmark in the 11th and 12th centuries, most likely owned by potent members of the Danish society. So far, the archaeological record does not reveal any ship-finds of German origin in Danish waters in the examined period, in spite of the historically known German commercial seafaring in the North Sea and in the Baltic Sea since the end of the 12th century. Future archaeological research is needed to throw more light onto the early history of Hanseatic seafaring in Danish waters and the kind of ships which were used by Danish and German merchants in the 13th century.

Acknowledgements

This paper is based on the results of a doctoral dissertation on the archaeological evidence of cargo ships of over 14.5 m length from the medieval Danish coasts dated to the period 1000–1250. I would like to thank all involved archaeologists and staff of the National Museum of Denmark, the Viking Ship Museum in Roskilde, the Viking Ship Museum in Oslo, the University of Bergen, the Museum of Haderslev, the University of Kiel, the Archaeological Service of Schleswig-Holstein (ALSH), the Archaeological Museum of Schleswig-Holstein in Schleswig, for their friendly support and advice. I owe special gratitude to Ole Crumlin-Pedersen for enabling me to do these studies.

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42. Remarks on the Identification of Medieval Ship Types in Northern Europe

Timm Weski

Though the term cog is well known – in fact it is in German almost synomymous with the Hanseatic League – the knowledge of its appearance was lost. Thanks to the research of Bernhard Hagedorn (1914), Walter Vogel (1915) and in particular Paul Heinsius (1986), it was possible to identify the cog as well as the hulc among the large number of Late Medieval ship names on iconographic evidence. According to the definition by Heinsius, a cog is a high hulled, single masted, square rigged vessel with a straight or only slightly bend stem. Further he mentions clinker building and protruding deck beams. Thanks to this research is was possible for Siegfried Fliedner to identify a wreck discovered 1962 in the river Weser in Bremen as a cog.

After this discovery the specific building method of this hull was added to Heinsius' cog definition (for example Litwin, 1989: 153). The use of twice bend nails instead of rivets at the clinker seams, moss as caulking material which was kept in places by lathes fixed with butterfly shaped clamps, known as sintels (Crumlin-Pedersen, 1997: fig. 1.6 C.2). Massive knees as the junction between keel and stern or stem post, so-called stemhooks (Lahn, 1992: Blatt 16) and transverse beams with knees on top which are placed below deck level (Ellmers, 1979: fig. 1.6). Further it is of importance that the bottom planks in the midship area are parallel to each other. Only forward and aft where the hull is sharply built they are overlapping each other (Lahn, 1992: fig. 33). This last observation has not always been recognised by other researchers. Other items like longitudinal deck beams are of no concern for this article. Further the paper will omit the Mediterranean Sea where the term cocha was used for ships which were surely constructed differently from the Bremen wreck of 1380 (Ciciliot, 1998).

In the discussion following the discovery of the Bremen wreck of 1380, the question of origin and younger varieties of the cog type played an important role. In these considerations not only archaeological and written evidences were included but linguistic ones as well. With the help of these sources patterns were developed which were looking upon the cog and the hulc as basic types. Terms like "basic form", "constant element", "evolution" or "melting process" are clearly showing this way of thinking (for example Fliedner, 1969: 63. Own translation). Another example for these evolutionary considerations is the scheme of four basic types of medieval vessels into which all wrecks can be fitted (Crumlin-Pedersen, 1983: 7 fig. 3; Weski, 1999: 96). The intellectual background for these thoughts is an evolution in the Darwinian sense. This is also the foundation for the so-called typological method which is one of the important means of archaeological research (Kunst, 1982). But ships and boats like all other archaeological material are not bound to these rules. Instead the shape of the hull, the kind of propulsion or the technique of hull construction depend on local conditions, use, technical know how, available material etc. as Thijs Maarleveld has pointed out rightly (1995: 3).

The evolutionary thinking, where everywhere forerunners or later developments of the cog were sought, led to the identification of a clay bowl in an inhumation grave of the 2nd century BC in Northern Germany as a proto-cog (Ellmers, 1994: 33). On the other extreme there is a boat from Northern Wales dating to 18th century AD used for transporting slates, which was described as being built in cog tradition (Illsley, Roberts, 1979: 64). In the Ijsselmeerpolders in the Netherlands several wrecks were discovered which were constructed similar to the Bremen wreck of 1380, but were smaller than this vessel. As it is known from expressions like *coggo sive navibus magna* that the term cog applied only to large vessels these smaller ships were called cog-like (for example van de Moortel, 1991).

If one looks at various archaeological finds and ethnographic evidence, one can show how misleading it can be trying to show lines of development just by using one criteria only. At several wrecks from the Baltic Sea area starting with the Hjortspring boat and ending with the vessels of Gokstad and Oseberg, the frames and the planks are joined by lashings with are secured to clamps which are moulded out of the planks (for example Engelhardt, 1865: pl. 3, 10). Exactly the same technical solution can for example be seen on boats from Melanesia from the beginning of the 20th century (Finsch, 1909: 376 abb. 3 – 5). One of the characteristic feature of Scandinavian vessel from the Viking age is a massive maststep with an upright post at the forward side (Roberts, 1994: 14). This item is even used for distinguishing these crafts from those constructed at the southern shore of the Baltic Sea, assumed to represented Slavonic boat building traditions (Weski, 1999a: 96). On the Portuguese Barca Serranna from the river Mondego a similar maststep is used (own observation), which would be regarded as typical Viking, if found on a beach. Another example is a type of overlapping, flush seam which is known from the Bronze Age North Ferriby boats (Wright, 1990: fig. 4. 8 f). The same kind of seam can be seen on Chinese wrecks dating to the Song Dynasty (AD 961 – 1278) which were called rabbeted carvel seam by the excavator (Green, 1998: 284). Finally this type seams, which are labelled *verdeckte Klinkerung* (concealed clinker technique), can occasionally be found on local boats in Germany (Weski, 1999c).

Trying to identify a historic term whose character is not really understood among archaeological or architectural evidence can be very misleading; in particular, if a certain construction technique is intermixed with the historic term. For example many cathedrals are built in Gothic style, but this does neither mean that all Gothic churches are cathedrals nor that there are no cathedrals constructed in a different style as for example St Paul's in London. Returning to ships: for the definition of a vessel as a clipper, it does not matter whether its hull is of wood or iron, or if it is composit built. But after the discovery of the Bremen wreck of 1380 exactly this was done: the characteristic building technique of the hull was intermixed with the term cog and these technical details were regarded as characteristic for this type of historic ship.

It has been assumed that Medieval names were well defined and unmistakable for each other. Looking at other periods one can see that this is only seldom the case, as it has already been pointed out by Hagedorn (1914: 7). In late Medieval times the term "schutae" referred to small vessels with a ship value of under 18 Mark Lübisch, which were mainly used for local traffic on the Baltic Sea (Weibull, 1967: 56, tab. 5). In the 17th century two masted coastal vessels in Denmark were called "Skuta" (Thomsen, 1997: 298, fig. 5), while from the 18th century even three masted ones are recorded in the Stockholm area (Högnäs, 1993: 148). Nowadays in German the term "Schute" refers to an engineless barge. Even today several different types of vessels can be grouped under the same expression. A cutter is a single masted sailing vessel with an fore-and-aft mainsail and at least two staysails. A "Finkenwerden Kutter" is a ketch rigged fishing vessel, which is defined by its hull lines and not by its rig (Broelmann *et al.*, 1992: 41). A rowing boat with auxiliary sails is known as "Marine-" or "Jugendkutter". On the other hand cutter rigged coastal sailing ships are either called Jacht or Slup, for example "Schleswig-Holsteinische Jacht" (Szymanski, 1934: fig. 211), "Pommerische Jacht" (Szymanski, 1934: fig. 28) or "Rahslup" (Szymanski, 1934: fig. 33). Or think about the many varieties of Jacht, Jagd, or yacht, starting with ocean going Dutch East Indiamen (Green, 1977: 23) going on with fast dispatch vessels (Chapman, 1768: pl. XLII, 5) to present day pleasure crafts. Another example is the so-called Mackinow boat in the U.S.A. which refers to a bark canoe as well as to various kinds of plank boats (Cecil, 2001: 60).

In most cases wrecks are only partially preserved. This means that a clipper constructed by Donald McKay and a Marstrand schooner could archaeologically be regarded as belonging to the same type, if only the keel and lower strakes were found, because they are constructed in a similar way and have the same number of masts. Ships of the same period are often given a similar hull shape, which was fashionable at that time. A good example is the clipper bow at the end of the 19th and beginning of the 20th century which can be seen at all kinds of vessels. The same could also be true for Late Medieval times. For example on the Dreikönigsaltar from Rostock dated to *circa* 1430 AD, three different sizes of ships and boats are depicted, all showing a similar hull shape (Ellmers, 1981: 10). To avoid intermixing archaeological with historic evidence, an archaeologically definition for wrecks constructed similar to the Bremen wreck of 1380, the Ijsselmeer type, has been suggested (Weski, 1999b; Crumlin-Pedersen, 2000).

There are three cases in which the term cog can be connected to iconographic evidence on seals. Unfortunately we do not have a book called *"De navibus"* or something like that in which these examples are given as being typical for a certain type, instead the seals were described in documents. It must be remembered that the seals were characterised and not the ships on them. The vessel on the seal of La Rochelle from 1200 (Fig. 42.1, 1) was called: „*in alio vero sigilo erat imago cujusdam ligni ad similitudinem Cochae* (ship similar to a cog) *cum arbore et vello quadrato expenso*" in 1323 by a Genoese lawyer (Heinsius, 1986: 48). As the ship bears close resemblance to depictions which are indentified as nef, keel or galley it has even been suggested to delete this seal from the list of cog depictions (Ellmers, 1972: 59). The seal of Lübeck is known from three varieties dating to 1226, 1256 and 1281 (Fig. 42.1, 2 – 4). In a document from 1328 it was described: " ...*quandam litteram produxit sigilatam sigillo, in cuius medio quidam cogko sive liburna* (a cog or a fast sailing ship) *erat scultus cum malo erecto et duobus viris, quorum vnus in manu tenbat funem et alter remum, in cuius sigilli circumferencia continebatur: Sigillum burgencium de Lubeke...*".[1] This identification led to a long debate, but it is more likely that the vessel represents a ship of Scandinavian or Slavonic origin than a variety of the Bremen wreck of 1380 (Weski, 1999b: 361). Some researchers even considered that the ship represented a keel (Mott, 1990: 20). The ship on the seal of Stralsund from 1329

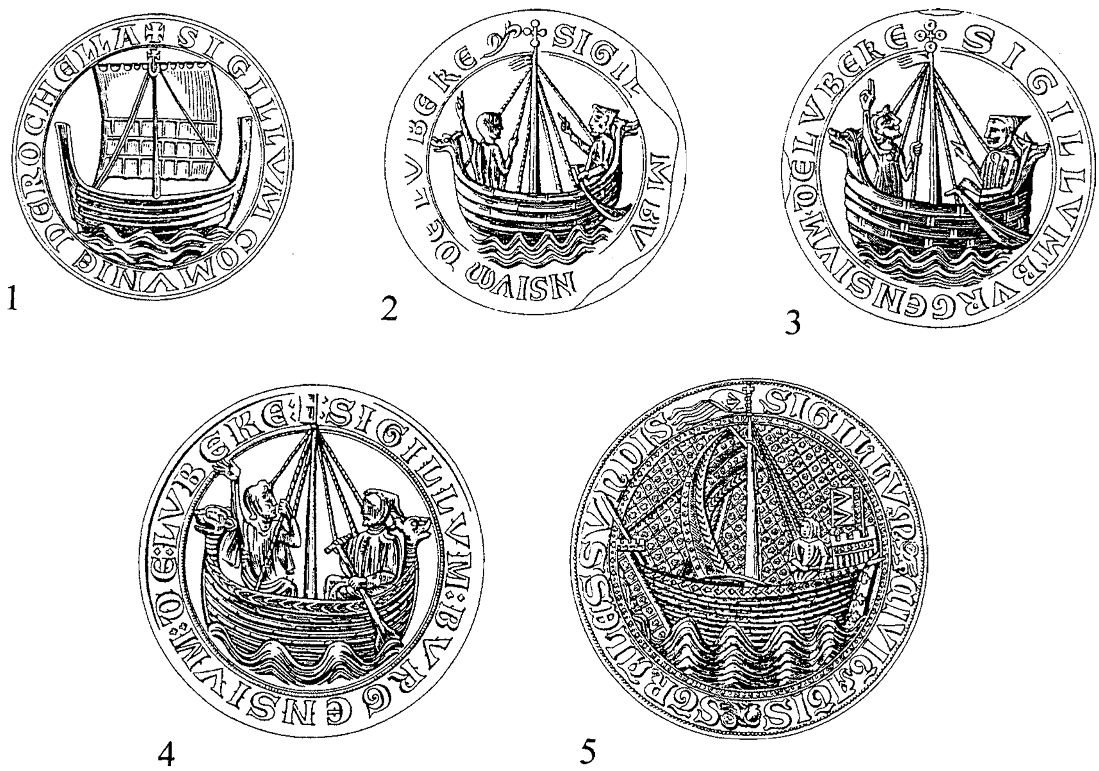

Fig. 42.1. Cogs on seals. 1 La Rochelle 2–4 Luebeck 5 Stralsund (after Ewe, 1972, n. 89, 91–93, 194).

(Fig. 42.1, 5) was called in a letter from 1483 as „...vnser Stad Sigel ghenomed den kogghen (our town's seal called the cog) wylyken laten henghen yn dussen vnsen breff“.[2] This description was one main reasons for the identification of the Bremen wreck of 1380 as a cog. Indeed the similarity between both vessels is striking as far as the silhouette is concerned (Lahn, 1992: Blatt 25). On the other hand the vessel on the seal of Stralsund could have been constructed similar to the undated model of Ebersdorf, *i.e.* with overlapping planks at the bottom and without sintels (Steusloff, 1983: 196). New finds from the Baltic Sea show that this construction method really existed (Förster, 1999: 77; Schmidt, 1999: 27). The cog on the seal could also have been built like the wreck *Kalmar II* which is dated not later than the 14th century and has been called a cog in the past (Ellmers, 1972: fig. 44). This wreck has a riveted clinker hull and a T-shaped keel indicating a Scandinavian origin (Åkerlund, 1951: pl. 10; 11), but it was possibly to reconstruct a hull shape from these remains, which looks similar to the vessel on the seal of Stralsund (Åkerlund, 1951: pl. 30). The missing protruding transverse beams on the seal of Stralsund could be regarded as a first hint that the ship was perhaps constructed differently from the Ijsselmeer type scheme, if one does not want to regard this omission as an artist's mistake. Putting the different evidences into a graphic, one gets a term cog which is characterised by three completely different seals and archaeological remains (Fig. 42.2). A connection with the Ijsselmeer type exists through the Bremen wreck 1380. The relationship with the model of Ebersdorf and the wreck *Kalmar II* remains open

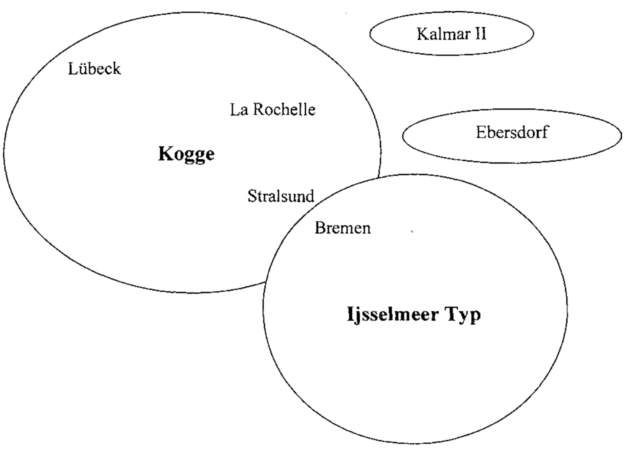

Fig. 42.2. Relation between cogs depictions and archaeological evidence (drawing: author).

The question arises whether all vessels looking similar to the seal of Stralsund are really representing cogs. If one compares the seal of Kiel from 1365 with those from Stralsund or Elbing from 1367 (Fig. 42.1, 5, 3), one gets the impression that the vessel on the seal of Kiel is smaller

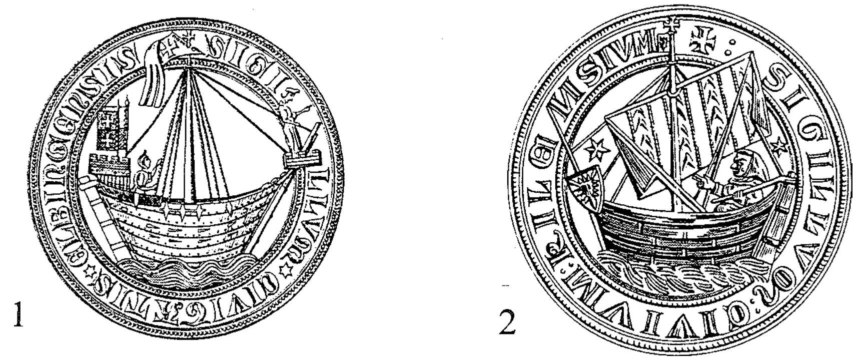

Fig. 42.3. Ships on seals. 1 Elbing 2 Kiel (after Ewe, 1972, n. 42, 83).

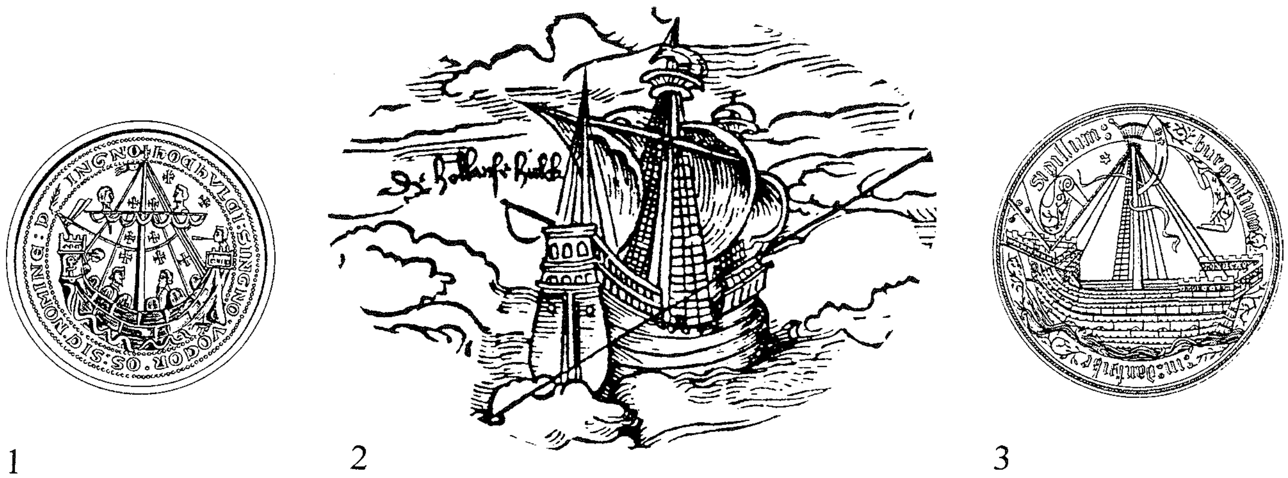

Fig. 42.4. Hulks. 1 seals of New Shoreham 2 Dutch Chart 3. Seal of Gdansk (after Ewe, 1972, n. 53, 127; Hirte et al., *1989: 572).*

than the others, because it has no castles and the number of strakes is less. The different size of the men on board should better be neglected. Perhaps the vessel on the seal of Kiel was so small that it had not been called a cog by the contemporaries.

The hulc is the second Medieval type of vessel whose identification in pictoral and archaeological evidence had been tried (for example Ellmers, 1999/2000). Again there are three completely different depictions. On the seal of New Shoreham from 1285 the term hulc can be seen (Fig. 42.4, 1). On a Dutch map of 1582 a three masted vessel whose hull form can best be characterised as that of a carack is labelled as "de hollandsche Hulck" (a Dutch hulc) (Fig. 42.4, 2). Finally there is the seal of Gdansk from 1400 (Fig. 42.4, 3) which in 1645 was described: „Das Grosse Siegell ist eine grosse alte Holcke, oder Schiff (a big old hulk or a ship), mit dieser Umbschrift: *Sigillum Burgensium in Dantzigk*, und wird alsdan gebraucht, wenn etwan Brieffe und dergleichen Schriften mehr, im Nahmen aller Ordnung abgehen, und ist in der Cämmer-Herren Verwahrung" (Curicken, 1686: 148). Nowadays a hulk is an unrigged sailing vessel which is used for storage purposes or a derelict hull on the beach.

Inspite of this rather confusing situation, attempts have been made to define a hulc as an archaeological type. Starting with the seal of New Shoreham in combination with other iconographic evidence a stemless full bodied hull with upbending strakes had been postulated (Greenhil, 1988: 64). The only ethnographic evidence for this kind of construction is known from river boats from Bangladesh (Greenhill, 2000: 3). Some researchers also tried to identify a hulc among archaeological finds. The first one is a reused part of a hull from London, Bull Warf, dated to 966/990. Its overlapping oaken strakes are fastened to each other with treenails and sintels. Moss is recorded as a luting material. The oak trees have either grown in Northern Germany or in the Netherlands (Goodburn, 2000: 221). It is interesting to note that the same find have been assumed to represent an early cog in another publication (Goodburn, 1997: 31). The wreck U 34 dating to the 15th century from one of the Ijsselmeerpolders is also called a hulc by the excavator (Reinders, *et al.*, 1987: 115). This hull has a predominant keel with a straight stern which does not suit with iconographic evidence. The clinker planks are joined with rivets and sintels. Again moss was used for caulking. The lower strakes are let into the stern post by a step-like rabbet, thus indicating strongly upbended planks. The upper strakes are ending in a straight rabbet. The third evidence is the so called copper wreck off Gdansk (Litwin, 1980: 219). This vessel also had a strong keel and the riveted clinker planks were thightened with the help of animal hair. At the lower end of the stern there is also a step-like rabbet. Comparing these three wrecks with the hulc depictions one has difficulties to find common criteria for defining this group of vessels.

From written sources several names for ship types apart from cog and hulc are known. Some of them are only of regional importance like the "bordnic" which was mentioned in a document from Stettin in 1281 for the first time (Rudolph, 1969: 52). Others are appearing in written evidences over a long period. It must be remembered that in most cases the characterising of the vessel was not the main aim of the writer. Further it is doubtful whether certain items like building technique or hull shape were familiar to non-sailors. Sometimes one gets the impression that the terms for the ships were chosen due to stylistic reasons. For example Henric of Lettland is usually calling the ships of the Germans *"navis"*. Only in certain cases when he is talking about several vessels he is using different expressions. A good example is the battle of the German pilgrims against the Kuren in the sound between Gotland and Fanö in 1210. The vessels of the Kuren are called *"pyraticae"*, while those of the Germans are labelled "coggae". Smaller boats were described either as "minores naves" or as "cymbae".[3] Sometimes names were connected with a certain ethnic group. For example the vessels calling from Rügen which in 1224 were hired by Lübeck merchants for transporting herring were known as *"ratis"*.[4]

In three cases the same vessel was called a cog as well as a hulc. In two of them this is done in different documents[5] and in the third case one name is referring to the vessel itself while the other one concerns the cargo in it.[6] There are also two letters from the council of Lübeck to that of Wismar warning them of pirates in 1422: :"...jodoch tom Kyle bereden syk de vitallienbrodere unde menen syk van stund in de see to legghen mit XVI efte XVIII *snykken* unde mit eneme *kregere* van LXX lesten, darto menen se noch twe grote *schepe* to verdeginde, ouer de en konen noch so drade nicht rede werden...".[7] In the letter to the leader of the fleet against the pirates they are speaking about: "...jodoch te dem Kyle dar willen se vtlegghen in de se vnnortghend mit XVI efte XVIII *snikken* unde mit eneme *euere* von souentich lesten, darto bereden so noch II *kreyere*, ouer de en kanen so drade nicht rede werden".[8] The term "snikke" in different spelling is the same, but the kreyer has became an ever and the ships have changed into kreyer.

On the other hand there must have been differences for the contemporaries between the various terms. In a document concerning the robbery of ships by the duke of Schleswig in 1342 a cog and a holc are mentioned.[9] The regulations for lighthouse dues on the river Maas in 1358 are reading:„...elc scip, het si coghe, eever of hulc...".[10] In 1401 in a description of the river Swin several types of vessels are noted: „ ...men legge langhes den strome te wetene de cogghen, schepen, crayers, evers ende barghen dre schepe dicke de en neffens den anderen, pleyten, cleene cogghen, schepen van Brabant, de Hollandesche, Zeelandesche unde van anderen vre[m]dem steden viere schepe dicke de en neffens den anderen, ende de schuten ende soyen 6 schepe dicke de en neffens den anderen, wel gheankert voren ende bachten".[11]

In a few Late Medieval written sources information about the sizes of vessels and their names are laid down (Fig. 42.5). As one can see from the table there is a broad variety of names for ships under 90 Last. This result has to be treated with caution, because the number of namings is rather limited. Further half of the evidence goes back to the bookkeeping of the German Order after 1400. It must therefore remain doubtful whether such naming can really be compared with those for example concerning an English fleet in 1242. Therefore this table is showing only a tendency.

It has been calculated that the Bremen wreck of 1380 could carry 76 to 84 metric tons, which has been converted to 38 to 42 "Lasten" of rye (Heinsius, 1986: 237). Using the figure given by Wolf one gets 33/34.3 to 36.5/37.8 "Lasten" of rye (1 Last of rye = 2217.6 – 2298.2 kg) (Wolf, 1986: 54) or 40 to 44 "Lasten" of herring (1 Last of herring = 1896 kg) (Wolf, 1986: 68). With this loading capacity the vessel belongs to Wolf's group III (1986: 133). This means that the Bremen wreck was not necessarily called a cog by contemporaries.

In 1368/69 a special tax was levied by the Confederation of Cologne for the war against Denmark. Fortunately the tax roll from Lübeck, apart from those of some other towns has survived. In this Pfundzolliste of Lübeck the value for each ship is also given (Lechner, 1935: 506). Though there are several inconsistencies as the value for the same vessel can vary considerably (Weski: in press), this figure can with some caution be converted into cargo capacity relaying on Wolf's research (1986: 132). Roughly speaking a ship value of 1 Mark Lübisch equals 1 Last cargo capacity for larger vessels. Looking at this table one can see that more than half of the vessels calling at Lübeck during this period were below 90 Marks Lübisch or 90 Lasten (Weski, 2002: fig. 9). Comparing this with the result of the other table this means that the majority of ships can neither be called cog nor hulc. Therefore there is no reason why every Late Medieval wreck which has not been built in Scandinavian manner should be given one of that names.

Why Late Medieval sailors called one ship a cog, another one a holc or a third one a kreyer remains mysterious (Fig. 42.6). The question arises whether certain details like sintels or the use of twice bent nails which are of great importance

Größe in Last	Schute	Ewer	Bardze	Kreyer	Kogge	Holk	Jahr	Quelle
7 – 9	X						1462	Vogel S. 505
14	X						1416	Vogel, Tab. II
15				X			1454	Vogel S. 502
20				X			1408	Vogel, Tab. II
24				X			1403	Vogel, Tab. II
25		X					1387?	Vogel S. 500
30				X			1449	Wolf S. 22
32					X		1242	Heinsius S. 101
34–36				X			1407	Vogel S. 501
30–40		X					1462	Wolf S. 21
43				X			1411	Vogel S. 501
45					X		1242	Heinsius S. 101
50		X					1456	Vogel S. 501
51					X		1387	Vogel S. 494
ca. 60		X					1358	Vogel S. 500
60				X			1420	Wolf S. 21
60					X		1387	Vogel, Tab. III
65				X			1408	Vogel, Tab. II
70		X					1408	Vogel S. 500
70		X		X			1422	Wolf S. 21
80			X				1449	Vogel S. 499
80				X			1407	Vogel, Tab. II
90				X			1411	Vogel S. 502
90				X			1407	Vogel, Tab. II
90				X			1411	Vogel, Tab. II
90						X	1402	Vogel, Tab. II
90						X	1411	Vogel, Tab. II
90					X		1242	Heinsius S. 101
90						X	1408	Wolf S. 20
90?						X	1460	Vogel, Tab. III
95					X		1403	Vogel, Tab. III
100				X			1408	Vogel, Tab. II
100						X	1403	Vogel, Tab. II
100						X	1406	Vogel, Tab. II
100						X	1408	Vogel, Tab. II
115					X		1407	Vogel S. 494
118					X		1241	Heinsius S. 95
120						X	1403	Vogel, Tab. II
120						X	1407	Vogel, Tab. II
120						X	1408	Vogel, Tab. II
120						X	1451	Vogel, Tab. III
120					X		1338	Heinsius S. 102
125					X		1241	Heinsius S. 88f.
130						X	1402	Vogel, Tab. II
ca. 130						X	1403	Vogel, Tab. III
130						X	1404	Vogel, Tab. II
130						X	1410	Vogel, Tab. II
130						X	1411	Vogel, Tab. II
130						X	1439	Vogel, Tab. III
140						X	1402	Vogel, Tab. II
140						X	1404	Vogel, Tab. II
140						X	1409	Vogel, Tab. II
150					X		1403	Vogel, Tab. II
150						X	1409	Vogel, Tab. II
150						X	1409	Vogel, Tab. II
180						X	1438	Vogel, Tab. III
200						X	1416	Vogel, Tab. II

Fig. 42.5. Types of ships and cargo capacity (after Vogel, 1915; Heinsius, 1986).

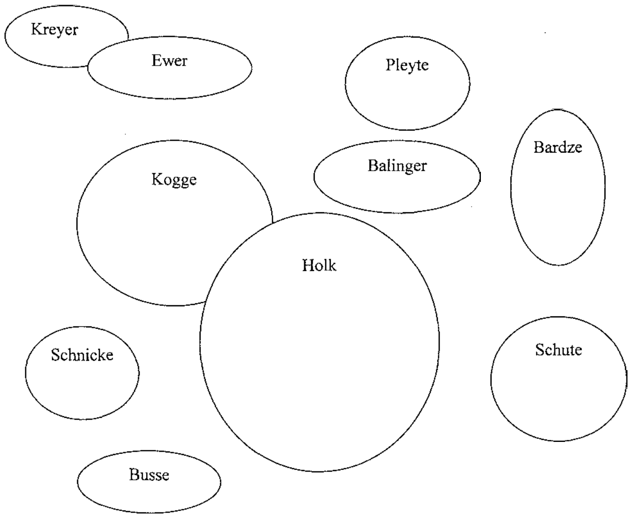

Fig. 42.6. Relation between late medieval types of ships (drawing: author).

to ship archaeologists did matter at all. Therefore it seems more logical to use new names based on archaeological definitions, for example London, Bull Warf or type U 34 instead of the vague historic name holc. Or Ijsselmeer type for hulls constructed similar to the Bremen wreck of 1380 in place of cog or cog-like. This applies also to other periods as well: type Black Friars or type Zwammerdam instead Celtic shipbuilding. It should be remembered that in land archaeology the custom of giving historic names has long been abandoned. Nobody will any longer call an Early Medieval grave with a certain number of grave goods as that of a nobleman. Instead terms like Qualitätsgruppe A, B, C or D have been introduced successfully (Christlein, 1973: 148). The fact that Thomas Wolf did not use historic names for his division of ships into groups of different sizes, could also be regarded as step into that direction (Wolf, 1986: 120). Up till now we talked about cogs when we really meant the building technique of the Ijsselmeer type. Perhaps we can avoid the confusion resulting from this mixture of different sources, if we restrict ourselves to new expressions based on archaeological analysis only.

Notes

[1] *Codex Diplomaticus Lubecensis.* Lübeckisches Urkundenbuch 1. Abtheilung Urkundenbuch der Stadt Lübeck II. (Lübeck 1859), I: 489.

[2] Stralsunder Stadtarchiv Urkunde Nr. 1765. Quoted after: S. Fliedner, *Die Bremer Kogge.* 2. Auflage. Erweitert und neu bearbeitet von R. Pohl-Weber (Hefte des Focke-Museums Bremen 19) Bremen, 24 footnote 10.

[3] Heinrici, *Chronicon Livoniae.* – Heinrich von Lettland, *Livländische Chronik.* Ausgewählte Quellen zur deutschen Geschichte des Mittelalters. Freiherr vom Stein–Gedächtnisausgabe, 24 (Darmstadt 1959), XIV: 1.

[4] C. G. Fabricius, *Urkunden zur Geschichte des Fuerstentums Ruegen unter den eingeborenen Fuersten* 2 (Stralsund 1843) n. XVII.

[5] *Die Recesse und andere Akten der Hansetage* (Leipzig 1870 - 1897), I: 5 nos. 46, 54; I: 6 nos. 509 § 33; 528 § 5.

[6] *Die Recesse und andere Akten der Hansetage* (Leipzig 1870 - 1897), I: no. 343 § 35; 48.

[7] *Codex Diplomaticus Lubecensis.* Lübeckisches Urkundenbuch 1. Abtheilung Urkundenbuch der Stadt Lübeck II (Lübeck 1859), I: 6 no. 415. Own emphasis.

[8] *Codex Diplomaticus Lubecensis.* Lübeckisches Urkundenbuch 1. Abtheilung Urkundenbuch der Stadt Lübeck II (Lübeck 1859), I: 6 no. 416. Own emphasis.

[9] *Hansisches Urkundenbuch* (Halle, Leipzig 1876 - 1939),II: no. 725.

[10] *Hansisches Urkundenbuch* (Halle, Leipzig 1876 – 1939), III: no. 414.

[11] *Hansisches Urkundenbuch* (Halle, Leipzig 1876 – 1939), V: no. 509.

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43. Rare Fragments of a 13th Century Clinker Galley found in London and Use of the Irish Wildwoods for Shipbuilding

Damian Goodburn

Introduction

Archaeological work in Greater London over the last 30 years (especially the last 20) has revealed remains of several phases of the port from Roman to post-medieval times (Milne, 1985; Milne, Milne,1982; Saxby, Goodburn, 1998). A small number of wrecked or abandoned vessels have also been found of Roman, medieval and post-medieval date (Marsden, 1994; 1996). In addition many reused sections of ship and boat hulls and individual nautical timbers have been found well preserved in the waterlogged river bank zones which extend well back from the current courses of the Thames and its tributaries (Goodburn, 1988; 1991a; 1997; Marsden, 1994, 1996). This large collection of material spans the Anglo-Saxon to late post-medieval periods (*ca.* 900–1800). The *corpus* is large, mostly, recorded in detail and usually closely dated. It clearly shows trends in changing styles of ship and boat building and changes in the raw materials used by maritime craftsmen of all kinds from shipwrights to sawyers and ship smiths (Goodburn, 1991a; 1999).

The discovery of the galley fragments

In the spring of 1999, the Museum of London Archaeology Service (MOLAS) carried out excavations prior to the redevelopment of a site at 'More London Bridge' close to the south bank of the Thames in Southwark , central London. (MOLAS site TYT98, – Bluer and Saxby, 2000). This work revealed the remains of a series of late medieval fish ponds. In one case a small rectangular pond was lined with chalk walls, which covered up an earlier lining made of round oak and elm piles and old clinker ship planking. The clinker ship planking was very robust, mainly in large articulated slabs and clearly from a large vessel or vessels. From the first, the excavators realised that the ship planking had a rare feature of 'odd shaped holes' in it.

This writer was asked to assist with the recording of the ship planking and it was immediately apparent that the unusual holes were typical medieval oar ports ('orlokes') (Fig. 43.1). The finds within the fish pond were of 14th century character which was initially thought to have been the date of the ship hull sections. Finds of vessels or parts of vessels of the late 13th and 14th centuries are uncommon in the London area but not unknown (Marsden, 1972; 1996: 55; Goodburn, 1991a). However, no clear material evidence of the remains of a large high medieval oared vessel had been found in the London region or the rest of Britain, although their existence was known from a variety of documentary sources such as the galley building account books of 1294–6 (Hutchinson, 1994:150; Friel, 1995:14). Whilst the historic records contain several words for oared vessels above the size of a boat their use is obscure and precise meaning unclear although the word 'galley' appears to refer to large clinker built vessels and is used here for ease of reference.

The recovery and recording of the galley fragments

The spread of clinker ship planking covered parts of the western and northern sides of the pond in a mixture of large articulated slabs and separate dissarticulated boards. The area covered with ship planks was approximately 9 m long by about 1.2 m high in all. Most of the boards were laid on edge, some up side down compared to how they would have lain in the ship. The planks were all of very varied character, and initially appeared to be the remains of several different vessels, but it now seems that the variations were a result of several phases of repair and rebuilding of one old ship. The lifting and detailed recording of the articulated slabs of hull side clearly from the galley was seen as the priority given some limits on time and access. The visible sections were drawn in detail at 1:10 *in situ* and photographed, although some sections were partially obscured by the overlapping of the board sections.

The remains were kept wet and then gently cut into manageable sections around 2–2.5 m long, this meant each

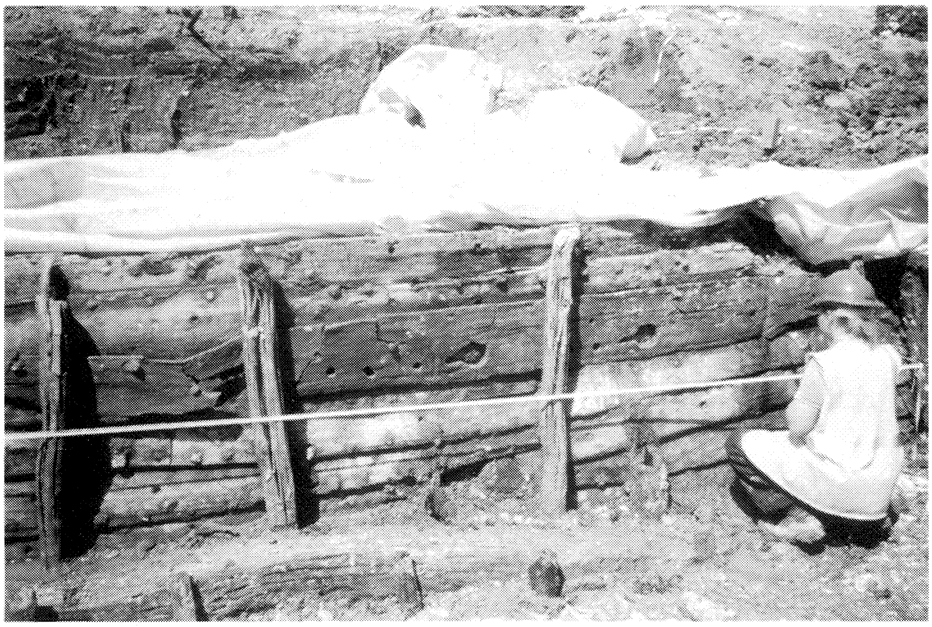

Fig.43.1 Some of the 13th century galley timbers as found, forming part of the lining of a fish pond, in Southwark, (MOLAS site TYT98). Note the oarports or 'orlokes' in the beech orloke plank (photo: author).

articulated section was cut in half. The sections were carefully eased onto polythene covered plywood sheets cut to shape and then secured and wrapped against drying during detailed recording at the Museum of London. At the museum both inboard and outboard faces of the hull sections were washed and drawn by this author, with help from the Museums, Conservation Department. Photographs were also taken sometimes in oblique light to highlight the surviving toolmarks on the planking. Tree-ring samples were taken at this stage and dating and timber sourceing information obtained within two weeks (Tyers, 1999, and below). Samples of the 'paint' and waterproofing materials were also taken which will be analysed as the overall project moves into the next phase of post-excavation research. A small amount of fieldwork remains to be carried out on site (March 2001).

Temporary display at the Museum

Such was the public interest in the ship remains, and other unique finds of medieval and 16th century date from the site, a temporary display was mounted immediately the recording and sampling was finished, about one month after lifting the hull sections. A clearly recognisable section of hull, including the beech orloke strake, was placed in a shallow tank in which the water was circulated and cleaned regularly. The beech strake was far more degraded than the oak planking having been found cracked into many touching sections with little ability to support themselves, and required the use of discrete supports. The Museum's conservation team have commenced a phase of PEG pre-treatment which will be followed by freeze drying. There are no serious reasons why this kind of temporary public display of waterlogged ship remains could not be used more widely as the level of public interest is clearly high as shown by the thousands of Londoners and visitors who viewed the material the few weeks it was on display.

A summary of the tree-ring study based on work by I. Tyers

This work was carried out by I. Tyers of the ARCUS lab, Sheffield University, who has worked on many of the London nautical finds (Tyers, 1996). These notes are taken from the unpublished spot date report (Tyers, 1999) and it is hoped that a fuller report will be published in due course. A total of 10 samples were dated with high quality matches to reference chronologies from England , Ireland and western France. However, the best matches were found to sequences from a number of Irish medieval sites particularly those of Dublin and Waterford. 'T' values of over 9 were found to several Irish sequences and a 'T' value of 10.77 to the Dublin Winetavern St. chronology. The probability is thus, strongly that the dated oak planking derives from the Irish sea region most likely eastern Ireland. This fits well with the documentary sources which note the export of oak boards from Ireland in the 12th and 13th centuries for use in buildings and vessels (Salzman, 1952:245; Hutchinson, 1994:150). Timbers from the 11th century Viking galley *Skuldelev 2* have also been provenanced to the same general region using tree-ring matching (Bonde, Crumlin-Pedersen, 1990). Of course the sourcing of the timber does not directly indicate the place of building of the London Galley discussed here, but see below for further discussion of this point.

The dated Irish boards were slow grown (0.56– 1.74 mm per ring) and had clearly come from old trees in some cases samples had as many as 248 rings. Some of these boards had several sapwood rings. By overlapping the various felling date ranges using a sapwood allowance of 15–60 rings for Ireland, a felling date range of 1265 to 1287 AD can be obtained. One of the boards [780], noted as a possible board reused from an earlier ship had a heartwood only date implying felling after 1200, perhaps somewhat earlier than the other Irish material.

The clearly fast grown repair boards did not provide good samples for dating. The longest ring sequence of these boards had 78 rings including 14 in the sapwood with an average ring width of 3.52 mm but could not be dated. The beech orloke plank was sampled and found to be exceptionally slow grown with an average ring width of 0.63 mm and over 140 rings, but no date match could be found. It has recently become possible to tree-ring date beech sequences in southern Britain, which has been used with success in the case of the 13th century *Magor Pill boat* (Tyers, 1998).

The lifted galley hull sections: a summary description

THE LOCATION OF THE HULL SECTIONS RECOVERED IN THE PARENT VESSEL

Four separate articulated sections were lifted which detailed recording showed were as follows (Fig. 43.2):

a) A section of orloke strake of beech timber with two strakes of oak attached, approximately 5.2 m long from towards amid ships (Fig. 43.3a).
b) A section of hull side of four oak strakes perhaps halfway up the side from the transition of the mid ships to the stern run.
c) A section of four narrow hood ends at the stern.
d) A section of parts of four strakes including an oak orloke strake from very close to the stern (Fig. 43.3b).

The slope of the through-splayed scarfs, which were almost always cut to open aft to the water, was consistent in all the sections and showed they derived from the portside of the parent vessel. Similarities in the fastenings frame spacing, tool marks and finish showed that the remains derived from one vessel rather than several. The tree-ring study results also suggest that this was possible. Unfortunately no sections were found to refit each other, although sections (c) and (d) above must have lain close to each other in the parent vessel.

Key features of the galley remains

THE HULL PLANKS

All of the strakes were of several scarfed elements which were radially cleft oak planks or more properly 'boards' except [704] the beech orloke plank and [710] the oak orloke plank. The 5.2 m long beech orloke plank was tangentially faced and had some faint axe marks on it, but was somewhat worn and eroded so that it is unclear wether it was made from a cleft half log hewn to shape as in the earlier medieval tradition or sawn out. The widest broad axe mark found was 190 mm wide (Fig. 43.3A), but the tool used was clearly rather wider, with a fairly straight edge. The pattern of the nailing showed that this plank was not original but part of a rebuilding phase. The oak orloke plank was also apparently a repair, but had survived rather better and the surface bore the clear crossing saw marks and split triangle of the medieval 'see-sawing' method (Fig. 43.3b and Goodburn, 1992a:113). It was approximately 30 mm thick and over 3 m as found. Some axe marks overlay the saw marks in places showing that there had been some secondary shaping by hewing here and there. The bulk of the radially split hull boards were

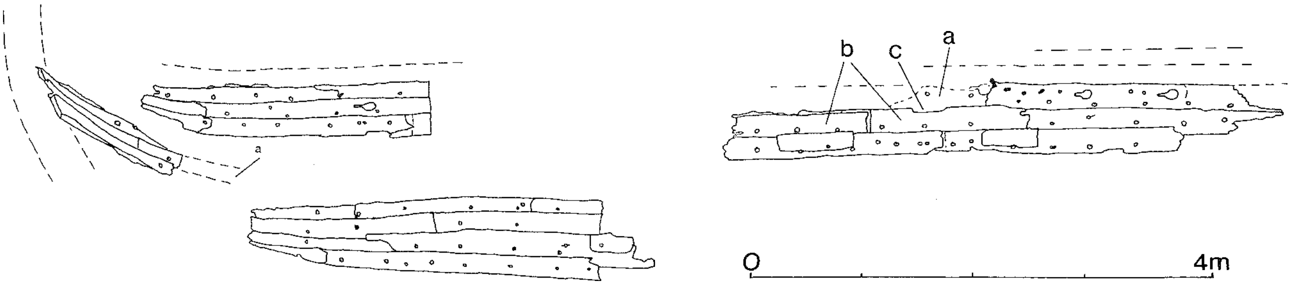

Fig. 43.2 The principal lifted articulated hull sections from the port side of the 13th century galley placed in approximately the original positions in relation to each other that they would have had in the parent vessel (lap fastenings not shown): a) fragments lost on lifting, b) fast grown repair boards, c) possible recess for a cross beam or thwart.

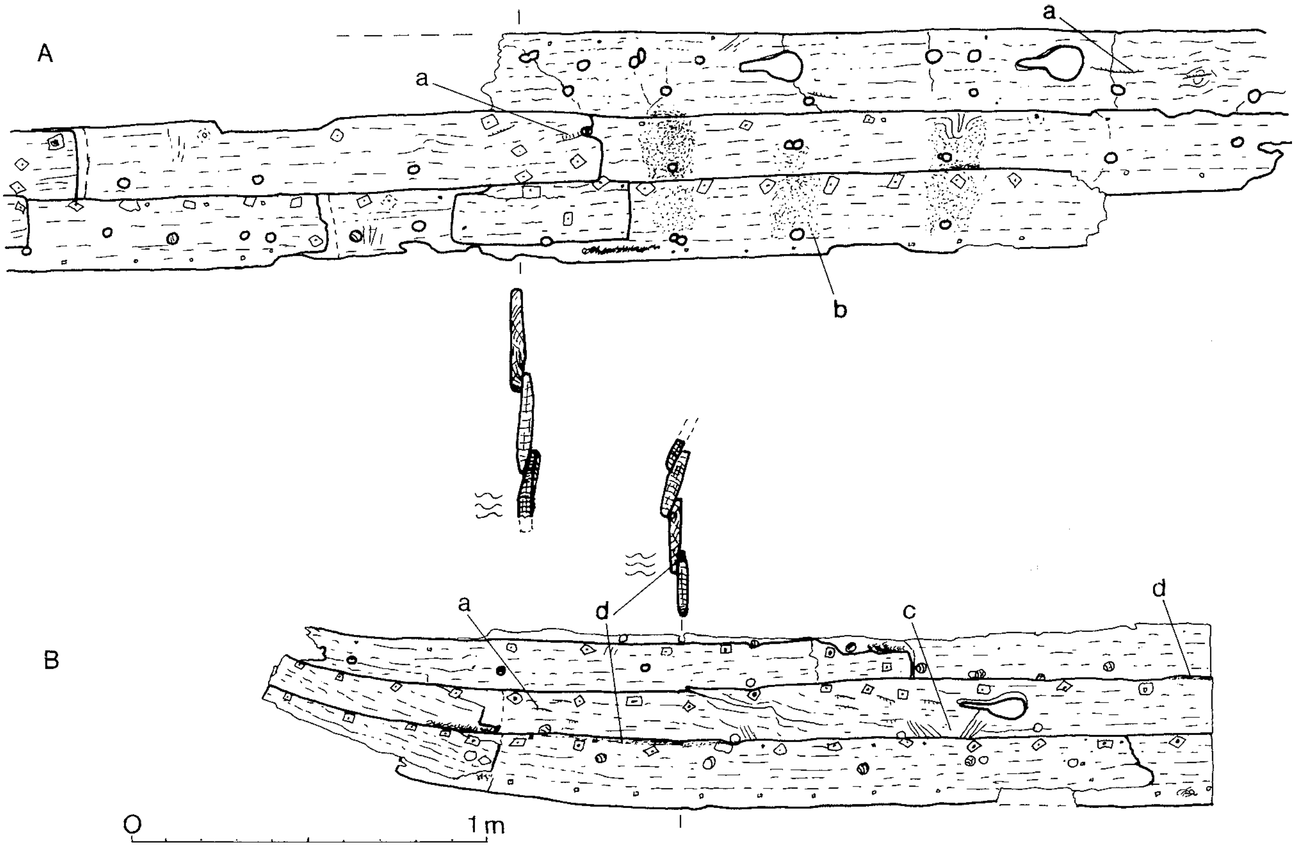

Fig. 43.3 Two sections of articulated hull planking from the 13th century galley found in Southwark, inboard faces: A) section including the beech orloke plank with oak boards below, from the ships waist; B) The sawn oak orloke plank with adjacent cleft oak boards from close to the stern: a) axe marks, b) tar surviving under where frames were fastened, c) split area where the crossing saw marks left by 'see-sawing' survived, d) sapwood on the plank edges.

carefully hewn out and substantially worn bearing only occasional faint axe marks. Most of these boards had had one fairly flat face with the other distinctively ridged (Fig. 43.3). These boards appear to be the original boards of the hull and are typically about 40–45 mm thick in the ridged section (a little thinner in the hood-end section) and were complete in the region of 2.5 m or more long. The clearly much less worn repair boards, scarfed to the above in places, were quite different, having a flatter lentoid cross section with a thickness of 30–35 mm and complete lengths of less than 1.8 m. The broad axe marks survived well on these boards from the smoothing after cleaving, which was done with only moderate care. The repair boards give the impression of cheap materials being used in a rough and ready way compared to the standard of work in the original vessel or other clinker ship-building work known from about the same date such as that in the three Kingston (Goodburn, 1991). Danish specialists in medieval ship archaeology have dubbed the vessel the 'ugly ship' as her strake runs would have been far from fair in her later life!

The planking was fastened with iron rove nails which had square shanks around 8 mm across, the roves varied markedly in size and shape. The frame fastenings were bulbous headed treenails of either 25 mm or 27–28 mm diameter. These were sometimes tightened by driving a small iron nail through them from outboard. Where treenail ends survived they were not oak but probably willow (samples to be checked) except in the case of the clearly later beech orloke plank which had oak treenails. Many of the boards had redundant nail holes plugged with oak bungs which were clearly related to rebuilding work such as the fitting of the replacement orloke strakes. However in one case, board [780], the holes were both bunged and then ran off the side of the strake showing it had been totally recut from use in another vessel.

THE FRAMING

Although no framing survived very clear impressions of where the timbers once lay could be seen on the inboard faces of the planking sections, particularly on the beech orloke section (Fig. 43.3A). In this central part of the hull the locations of the frames was indicated both by the treenail positions and also the survival of a thick band of tar which would have lain under the frames. The tar was largely worn away between the frames. The impressions were consistent and indicated that the frame timbers were spaced on approximately 400 mm centres and had a siding of about 200 mm. Thus, the framing was heavy and closely set paradoxically more what one might expect of a heavy cargo vessel than a fast oared warship. The density of framing was about twice that of the large 11th century galleys such as *Skuldulev 2* or *Hedby 1* (Crumlin- Pedersen, 1997: 81). We have no evidence of the moulded depth of the framing elements.

The waterproofing and 'paints'

Although the ship was clearly old and very worn when broken up perhaps around 1300 AD, the surfaces of many of the planks were only slightly decayed or abraded. Thick deposits of degraded brown tar could be seen in many places on the inboard faces, in places it was so well preserved that it had remained black and smelt tarry, also water dropped on it ran off in beads. The tar was sampled and will be analysed but we can assume it was some form of wood tar. In some places on the plank surfaces traces of a creamy white deposit were also found which appeared to be some form of 'paint'.

This material, which was sampled, will also be identified. The survival of well preserved tar and traces of paint is rare in nautical archaeology, but such materials were once of considerable importance in shipbuilding for waterproofing, controlling weathering and decoration and the subject is perhaps under researched at present.

The oarports ('orlokes')

There is always considerable interest amongst sections of the nautical archaeological and naval history communities in the issue of how large early oared vessels were rowed including the galleys of this period (see Hutchinson, 1994: 151 for a summary of the debate concerning galleys of the 13th century). Here the raw dimensional data is presented for initial consideration rather than an extended analysis. Parts of three oarlokes survived in the beech orloke strake as found but only two clearly survived the lifting process such was the fragility of the timber (Figs. 43.1, and 43.3A). The spacing to centres was 0.76 m and 0.88 m. The orloke holes also varied in dimensions and were surprisingly small the circular hole in the beech planking was *ca.*100 mm in dia. and the blade slot 180–200 mm wide. These dimensions might suggest an oar of around 75 mm in the loom at the lock including any chafing materials, with a blade perhaps 170 mm wide. The single orloke in the oak strake from right near the stern of the vessel had a circular hole of only 80 mm perhaps implying an oar of only 65mm diameter in the loom near the lock. It seems to me that these oars could only have been pulled by one man. The documentary sources mention 'ashen oars' (Hutchinson, 1994:150), and ash is a particularly tough timber for oars still used in the 20th century for some workboat oars in England. The strength of good ash would allow it to be shaved down to a smaller size than the commonplace softwood oars of today in NW Europe. The orlokes were set at least two strakes down from the sheer at the stern and at least one, possibly two, amidships.

The origin of the boards and the varied types of woodland used, wild and managed

The potential of waterlogged nautical woodwork for the reconstruction of ancient trees and woodland has been realised for some time (McGrail, 1978: 31), but it has only occasionally been part of the study of ship and boat remains. The reliability of this work has been greatly aided recently by both experiments in early shipbuilding and advances in tree-ring studies (Crumlin-Pedersen, 1986; Goodburn, 1991b; 1992b).

Areas of largely natural, high, dark wildwood clearly survived in places in England until around the middle of the 13th century becoming scarcer in the decades before. The large diameter, tall, straight grained trees produced oak and beech that was very easily cleft into boards for many uses including ship building (Goodburn, 1998). In open types of managed woodland or wood pasture oak and beech trees grow more heavily branched and less straight and although they may achieve similar girths to the typical temperate wildwood tree of *ca.* 1 m at 200+ years old (Peterken, 1996: 154), they will usually have achieved it substantially less time perhaps 130 years or so. This produces strong but more awkwardly worked timber than wildwood conditions. We know from archaeological finds and documentary sources that radially split boards were still made in England after the disappearance of the ideal wildwood trees, but the work was much less common, more difficult and the boards were produced in shorter lengths down to as little as 6ft (*ca.* 1.84 m) by the early 17th century when the technique seems to have ceased in England (Goodburn, 1999: 173).

It would appear that the typically large slow grown straight oaks of temperate NW European wildwoods were available in some quantity in Ireland even in the late 13th century. The original Irish boards used in the galley must have come from trees or around 1 m in diameter and around 200 to about 270 years old with a very straight growth habit (Fig. 43.4a). They are material evidence of the late survival of the Irish Wildwood . This is particularly interesting in the case of Ireland which is now the most tree less country in Europe, large areas have no oak trees at all where the soil and climate would be suitable. Dramatic deforestation is a strong European tradition and shipbuilding has played an important part in that process in some areas, although other demands for wildwood timber have also been important such as cooperage.

The beech used for the beech orloke strake may well

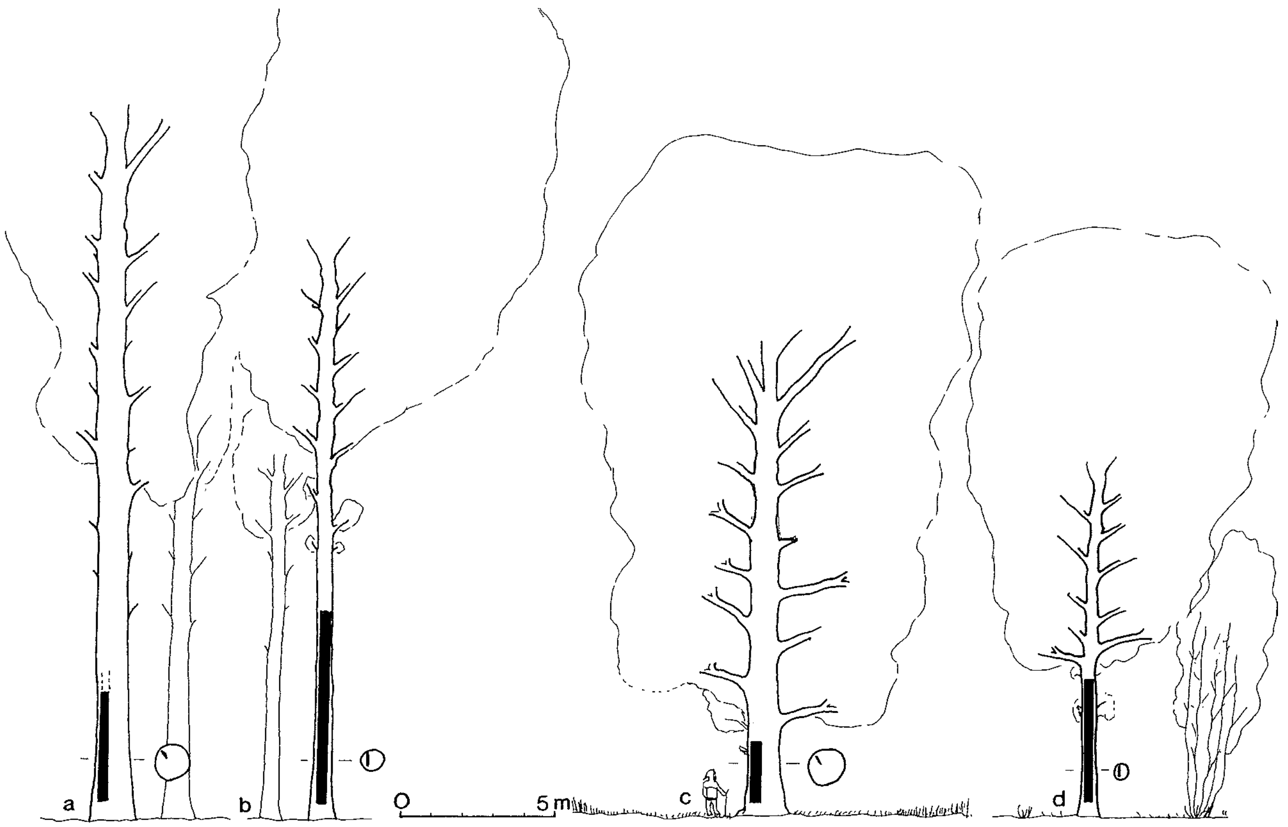

Fig. 43.4 The hypothetical 'parent trees' used for parts of the 13th century galley: a) large extinct Wildwood oaks growing in Eastern Ireland used for the original radially split boards of the hull; b) the large, straight, slow-grown, beech used for the beech orloke plank, growing in SE Wales or southern England; c) large, fast-grown oak from a field or woodpasture type setting for the repair boards, probably in southern England; d) a modest sized, fairly fast-grown oak typical of a 'standard' in managed coppice with standards woodland characteristic of later medieval southern England. Used for the sawn oak orloke plank.

have been a broadly similar parent tree but younger and of smaller in girth (Fig. 43.4b). However, the short later repair boards were clearly cleft from fast grown oaks that were of similar girth but only straight grained for short lengths (Fig. 43.4c). Such oak is typical of most other structural woodwork in later medieval England. One of the great advantages of sawing technology was that smaller knottier trees could be used to produce longer boards that although somewhat prone to splitting were eventually seen as advantageous for the cost-aware shipbuilding of the later medieval period. The see-sawn oak orloke strake of this galley was sawn from such a slightly crooked smaller oak only about 0.40 m diameter at chest height, a modest tree. This timber and one sawn wale from the *Kingston 3* vessel represent the earliest examples of the use of sawn timber in keel-type clinker built ships found in England.

SOME INITIAL CONCLUSIONS

The chance find of these fragments of a large oared vessel has given us a first material glimpse of what is a rarely found class of ship at this period. The English galley building account books of the period show us that the sizes of the galleys varied considerably, but they could be as much as 100ft (30 m) on the keel perhaps 140ft overall (Hutchinson, 1994: 151). This example of the vessel type was surprisingly heavily built although rowed by comparatively light oars, probably wielded by single oarsmen. The vessel may have been relatively carefully built initially but appears to have passed through a phase when she was crudely and cheaply rebuilt with cheaper materials such as beech timber and short fairly roughly finished oak boards. A great deal of tar was used to keep her tight in later life and she was probably broken up around 1300 AD or a little later when she probably became unseaworthy.

Detailed studies of the four main surviving sections have shown that the old technology of the early medieval galley builders using radially cleft boards shaped with broad axes was used alongside new materials borrowed from either carpentry practice or early cog building where sawn material had been used for about 80 years in England (Goodburn, 1997). The quality of materials and workmanship could fairly be described as showing the increasing cost-awareness of shipbuilders at this time.

The tree-ring study has validated suspicions derived from the historical sources that a galley found in England at this time might be of Irish origin or at least contain much Irish timber. An initial building in Ireland may be tentatively suggested for this vessel as she contained second hand boards also of Irish origin ([780]) and it is suggested that such material was probably not exported. However, it is clear that she was massively rebuilt and a new orloke strake added, which included one large beech plank. Beech is not native to Ireland and so this work must have taken place elsewhere possibly SE Wales or perhaps more likely somewhere in southern England. This work must have taken place within a few years of the great clinker galley building period of 1294–6. Future analysis of this material will include more detailed comparison of the find with the various surviving galley building accounts and some other broadly contemporary fragmentary clinker ship finds such as 'TG 9' from Dublin (McGrail, 1993:133) and the Kingston vessels which share some characteristics, and differ in others. It is hoped that eventually part of the vessel will be displayed at the Museum of London as a sample of London's medieval naval and shipbuilding past.

Acknowledgements

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44. Clenched Lap-Strake Boat Finds from the Netherlands, between 1200 and 1600

André F. L. van Holk

Introduction

Over a period of half a century, several ships have been excavated in the Netherlands, which share a technique of connecting the strakes, that seems unusual for the area. The strakes of these ships are overlapping each other and connected by rove and rivet or by rove and rivet and small treenails. In other words in this paper, clinker-built ships will be discussed, found in the Netherlands, with strakes that are riveted together or connected by a combination of rove and rivet and treenails. One of the ships to be analysed might contribute to the still ongoing discussion (and never solved problem) of, and search for, the mysterious holk. As my family-name is van Holk, please do not take this as an identity crisis. I mean of course the never traced – in the archaeological record at least – ship-type holk or hulk.

As the use of rove and rivet is not typical for the Low Countries, the first question to be answered is that concerning the origin of these ships: what was the home port of these vessels?

To answer that question, the three basic elements of a ship-find stand at our disposal: the attributes, in terms of construction, of the artefact itself (the ship), the composition of the cargo and the artefacts. When we analyse these elements together, in combination with each other, ships turn out to do more than floating alone. For a long time maritime archaeology has been reduced to nautical archaeology, that is, the study of the technological aspects of a ship-find. This approach is treating ships as if they float in empty space, but since we are dealing with ships and not Ufo's, we have to link ships to the society that produced them: otherwise ships are meaningless objects. In order to avoid this, the holistic approach of maritime archaeology is presented here, in which the ship, the ship-inventory and cargo are integrated to *construct* a piece of maritime history.

In a way this paper is a bad example of this approach, since it is confined to the construction, cargo and dendro-analyses of the ships; still these finds will be dealt with, because they are interesting in themselves.

So let me at least explain my approach in a theoretical manner. Firstly, if we look at the future, or to put it another way, if maritime archaeology is to become mature, we have to treat ships as integral artefacts. Secondly we have to give meaning to the ships we dig up. So we have to put our wrecks in their context, economic, social or otherwise. Ships function in a system, are part of a system.

For a long time maritime archaeology has been reduced to nautical archaeology, *i.e.* the technological aspects of a ship-find. The reason for this is that the reconstruction of the hull-form of a ship indeed needs a lot of attention. As a consequence in our field we just started off defining boat-building traditions. In fact we have to realize that we know very little about boats and ship-building traditions, apart maybe from the Scandinavian Viking period and the building tradition of cog-like vessels. At least we are beginning to get a grasp of the variations that exist in the cog building-tradition. A good example of a ship type that is still unknown in the archaeological record is the holk. So there is an excuse for our isolation from main stream archaeology (or maritime history for that matter), and focus on nautical archaeology: the basic material is full of gaps. Yet this is no excuse to treat ships as if they float in a vacuous space. So the first step in maritime-archaeological research is to analyse the construction and hull, cargo and inventory of the excavated ships. The often forgotten second step should be, to try to give meaning to the ships we dig up.

On to the situation in the Netherlands. As you know, the Netherlands are situated along the southern coast of the North Sea. The center of the Low Countries is formed by an inland sea (called the Zuiderzee). The IJsselmeerpolders are an area of reclaimed land in the Zuiderzee. The whole of the Zuiderzee has been shut off from the North Sea in 1932 by a large dam, some 30 km in length, and is now called IJsselmeer (IJssel-lake). In the IJsselmeerpolders 435 ships have been found, that are studied by the Netherlands Institute of Ship- and underwater Archaeology (NISA), based in the city of Lelystad.

Seven of the ships, to be discussed here have been found in the IJsselmeerpolders, and one in the city of Rotterdam (Fig. 44.1).

The ideal world, the model: connection of the strakes and luting

The essence of shipping is to move around with a certain purpose: to transport goods and people, to fight battles, to go fishing. We as maritime archaeologists should ask ourselves then: what is the reason for this particular ship to be in that particular place and at that particular time?

But before that can be done, we have to have an idea about some of the contextual factors of that ship-find: where does this ship come from? What date is it?

The study of the construction is one of the ways to get to know more about the origin of a ship. For the purpose of simplicity, only two constructional elements are selected in this study: first, the fastening of the overlapping strakes and, second, the way the seams between the planks are caulked.

According to Crumlin-Pedersen (1997: 29, fig. 1.6) in North-West European ship-building, in the Middle Ages and after, three techniques of connecting overlapping strakes were employed:

- First we have the fastening by rove and rivet or clenched nails, with luting of twisted animal hair; this kind of fastening is associated with Nordic vessels.
- The second manner consists of small treenails and moss or wool to make the seam watertight. This variant is associated with Slavic boatbuilding.
- The last type of fastening is with nails that are hooked over, and the point is hammered into the wood; caulking is with moss, covered with a lath, which is held in place by cramps. This way of connecting the strakes is associated with cog-like vessels and craft, of, for example, the former Zuiderzee.

These three fastening-techniques belong to three shipbuilding traditions and have correspondently also different areas of distribution (Marsden, 1994: 173, fig. 151).

Rove and rivet are typical for Scandinavia (Fig. 44.2), while pegging was done along the southern Baltic coast, and hooked nails can be found in the Rhine basin. So the fastening method of the strakes and the corresponding area of distribution are combined in a model, although the situation along the southern North Sea coast is less clear and obviously needs further study.

The question will be posed here how the ship-finds from the Netherlands fit into this model. Three ships do not fit in the model at all, because the strakes are connected by rove and rivet and by treenails at the same time. Yet another ship does fit in, but shows characteristics of a (postulated) Saxon boatbuilding tradition.

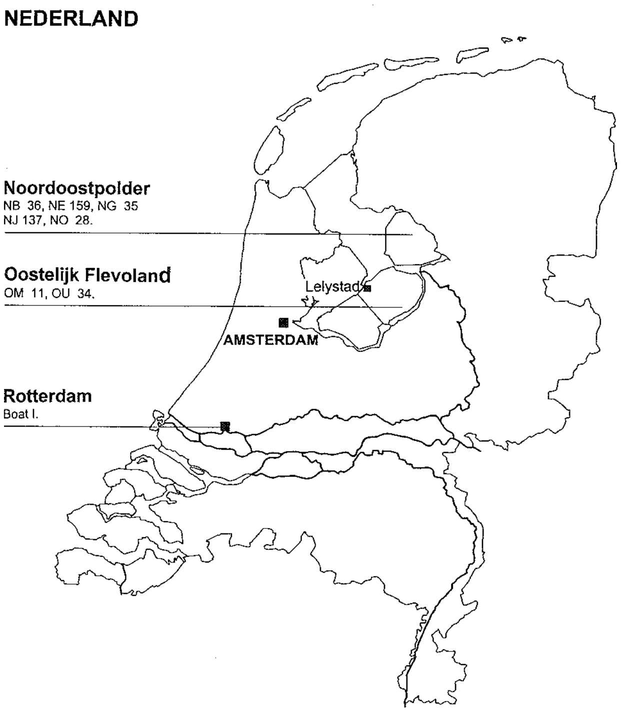

Fig. 44.1. Map of the Netherlands with sites of shipwrecks mentioned in the text (drawing: G.J. Zand, Netherlands Institute of Ship and underwaterArchaeology).

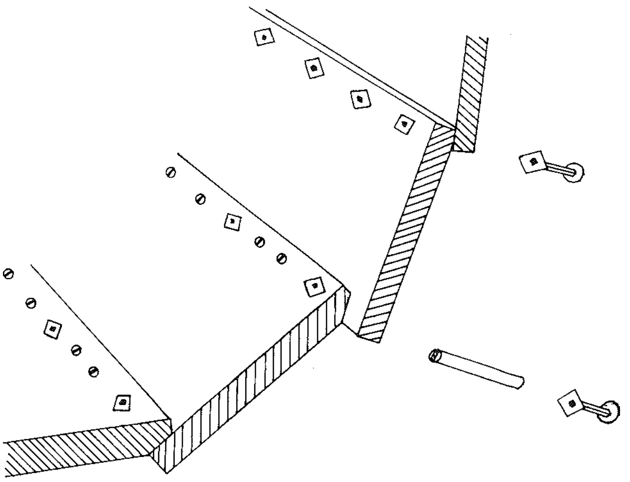

Fig. 44.2. Connection of overlapping strakes by rove and rivet and small treenails.

The empirical world: the ships themselves

First we will take a look at the ships with riveted overlapping strakes. The only substantial clenched lap-strake boat-find outside the IJsselmeerpolders is *Rotterdam boat 1*; it is also the oldest ship. She was found during work on a tunnel under the river Meuse in the city of Rotterdam, at a depth of twelve meter under present street level (Van Holk, in press a). Tree-rings were studied by the foundation

Ring.[1] The felling-date of the trees used to built the ship lies between 1252 and 1263.

She seems to have been of modest dimensions, with an estimated minimal length of 11 m. Nevertheless it could have been a seagoing vessel. The find is interesting in itself because it shows some striking details of construction: for example the way the keelplank is connected to a postulated sternpost. This is done by fastening a slowly raking beam with a long scarf on top of the keelplank. The strakes are riveted together, but a repair is done in the building tradition of the cog: part of a strake is replaced and fixed with twice bent nails. So the ship is presumably built and repaired in different places. For a ship this seems not remarkable, since ships move around. But considering the different worlds of these traditions, it is. Maybe the question should be: were these worlds so different?

The ships in the IJsselmeerpolders are coded according to the lot were they have been found. The code consists of two letters and a number. The codes are used to designate the various ships; the ship under consideration is found at lot NG 35 and explored recently in the summer of 1999.

The ship is still lying in the bottom, waiting to be protected at the site. The data are based on a survey and thus of a partial character. One sample was taken for dendro-dating: the resulting felling year 1422.[2] She is completely clinker-built, has a flat bottom with a hard chine, but fore and aft the underwater body is of fine fashion. The overall length of the vessel is almost 19 m.

Most interesting about this ship is the state of preservation. The sides are present untill the uppermost strake, so we could document part of the peculiar gangway or deck construction in the trial trench (Fig. 44.3). The ship could be characterized as a medium-sized cargo vessel. Some of the cargo was still present in the hold: a layer of oats.

As far as it is possible to judge from a reconnaissance

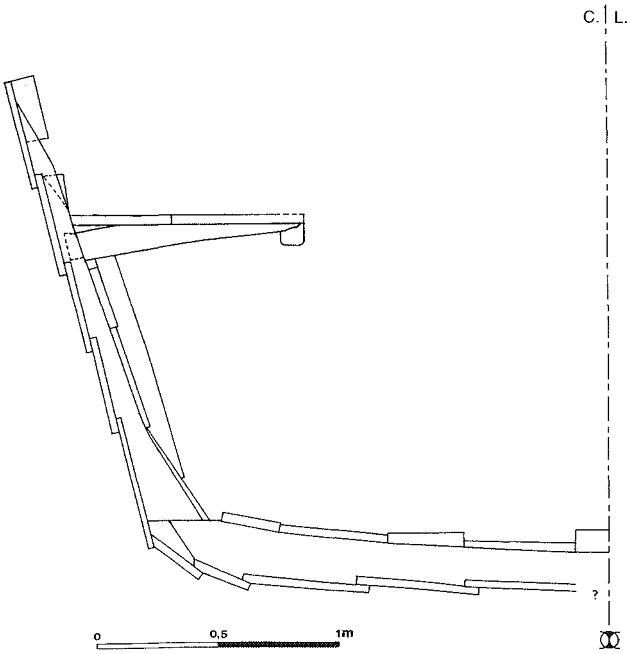

Fig. 44.3. Reconstructed cross-section of the ship found at lot NG 35 in the Noordoostpolder.

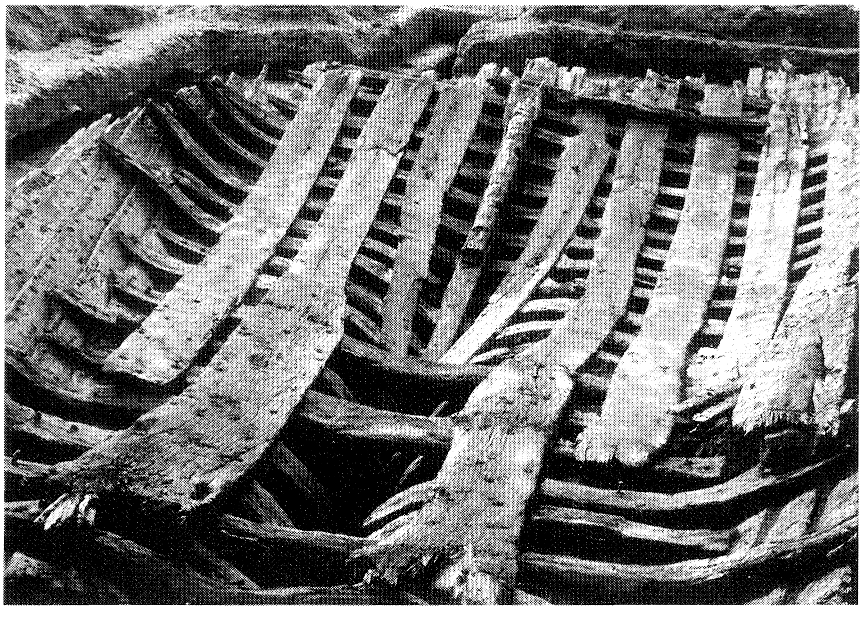

Fig. 44.4. View of the hull of the ship found at lot NO 28 in the Noordoostpolder, with ceiling, framing and hull-planking (photo: W. Potuyt, Rijksdienst voor de IJsselmeerpolders).

excavation, it also seems that the artefactual inventory forms an extraordinary well preserved assemblage.

The next six ships differ from the aforementioned two in the sense that they have a far closer range in their dating. The excavation of the ship at lot OU 34 (see below) in 1986 formed the incentive to look for comparable ship-finds in the archives of the NISA. Three ships with rove and rivet could be traced at that time.

The data on the first ship, found at lot NB 36, are scarce, because they are based on a survey. The narrow strakes are connected by rove and rivet with a rectangular shaft and spaced some 20 cm apart. The keel is rectangular and has a v-shaped rabat. The turn of the bilge is round. The minimal overall lenght of the ship amounts to 16 m, so we are dealing with a small-sized cargo vessel. The date of wreckage, based on the sedimentation, is estimated around 1500. There was no cargo or inventory associated with the ship.

The second ship is found at lot NO 28. The felling date of the timber is between 1530–1541.[3] This ship is completely excavated but only the back half of the ship was preserved. The hull is clinker-built, out of relatively narrow strakes, which are connected by rove and rivet. Concerning the hull-form, she has a flat bottom midships, while the stern has a flaring underwater body (Fig. 44.4). An interesting construction detail are the cross-timbers on top of the v-shaped crutches. They seem to be remnants of the *bitr* used in the Nordic ship-building tradition.

In the third ship, which is found at lot NJ 137, a variant of the rove and rivet technique turned up, with the rivet bent over the rove. The strakes of this ship are also narrow, and besides, of short length.

In this case again cross-timbers are lying on top of the crutches (Fig. 44.5). So this constructional element, too, might be a remnant of the Nordic ship-building tradition.

Only one dendro-sample was available, which could be dated between 1540 and 1546 (van Holk, 1986: 26). The use of rivets bent over roves has also been documented by Marsden (1994: 149, fig. 143) in the case of the *Blackfriars ship 2* find from London, dating from the 17th century.

The second group of clinker-built ships share the way the strakes are connected: rove/rivet and treenails. In 1986 a clinker-built ship was excavated in the IJsselpolders. This ship is of interest for several reasons. Due to the fact that the portside was collapsed over the bottom of the ship, a good deal of the hull was preserved.

The sheer dimensions must have been enormous at that time, with an estimated length of 30 m, a width of 9.5 m and depth of hold of 5.4 m. The ship has a rabbeted beam-keel, a curved stem and a straight stern post with a height of almost 7 m. Eye-catching are the big internal timbers, so-called riders, on the inside of the ceiling to give extra strength to the frames.

Might this be, then, a holk, the mysterious ship-type, never traced with any certainty in the archaeological record? Reinders and Oosting (1989: 113–117) already mentioned this possibility, but the evidence is still lacking.

Lots of samples were taken for dendro-analyses, but none could be dated at the time. Just recently a renewed

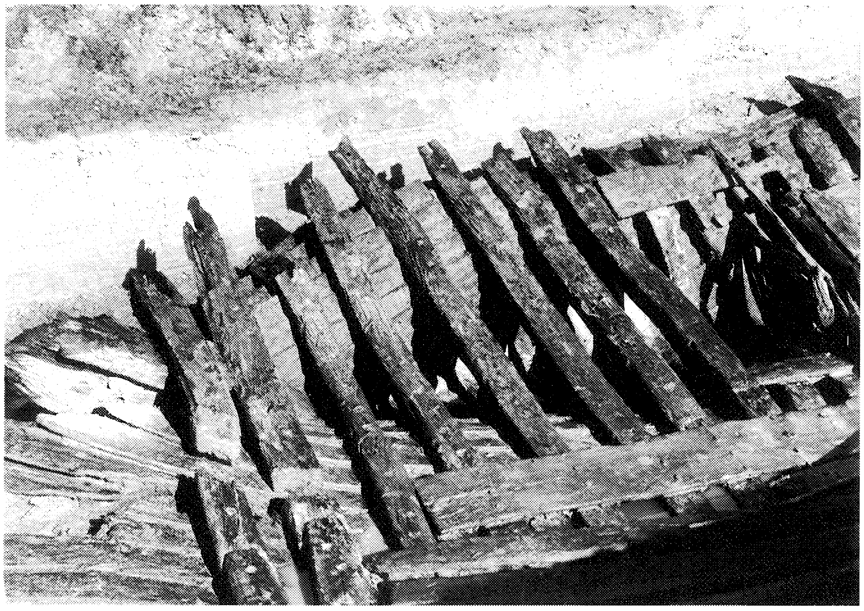

Fig. 44.5. View of the hull of the ship found at lot NJ 137 in the Noordoostpolder, with 'bitr', ceiling, framing, hull-lanking and cargo-floor (photo: W. Potuyt, Rijksdienst voor de IJsselmeerpolders).

synchronization (with newly developed reference curves) turned out to be successful. Three dendro-samples could be dated: the most likely felling date is 1528.[4]

The overlapping strakes are connected by rove and rivet and treenails, as far as the bottom and the transition strake are concerned. So two different building techniques are combined in one vessel.

The regular pattern of treenails alternating with clenched nails (every three treenails a clenched nail is used) reveals that it is not a matter of repairs. The strakes of the sides are connected by rove and rivet only. So this type of fastening does not fit in the already described model of connecting overlapping strakes.

In 1992 a cargo vessel was excavated at lot OM 11, with a length of 20 m and an approximate width of 5 m. Due to the fact that the port side of the vessel had collapsed to the outside, it was preserved above the gangway to the bulwark. The stem was slightly rounded; the raking stern straight. The turn of the bilge is hard.

The keelplank was rabetted to receive the sheerstrakes. The ship had a closed ceiling. The gangway was supported by hanging knees fastened to the ceiling and side. Dendro-analyses revealed a felling-date between 1531 and 1533.[5] so the ship can not have been built long after that. The overlapping strakes of the bottom and turn of the bilge are also fastened by rove and rivet, alternating this time with two treenails. The planks of the sides are connected, however, by rove and rivet only.

The last ship on row, shows a striking similarity to the one mentioned above: first in the manner of fastening the clinker-laid planks. Here we also see that exciting fastening, consisting of rove/rivet and treenails. The felling-date of the timbers, based on three samples, is 1506.[6]

The story of the excavation of this ship had a sad, premature ending behind curtains. In the Noordoostpolder she was dug up in 1963 at lot NE 159. At that time a lot of ships were excavated each year, in high speed. The ship was incomplete: only the back part and part of the starbord side were intact. The ship had supporting knees for the gangway, identical to the ones just mentioned for ship OM 11.

Although many ships were removed in that period, the excavators must have been struck by the presence of roves and rivets to connect the strakes, because part of the side of the ship was sawn out to be kept and transported to the workshop. Two photographs were taken, the ship-section stored – and that was the end of the story as an anonymous artefact. At that time it was not recognised that besides rove and rivet, small treenails were used to connect the strakes, and the piece was forgotten.

I traced this ship-fragment by chance in our workshop, it was conserved by (uncontrolled) slow drying. Only a

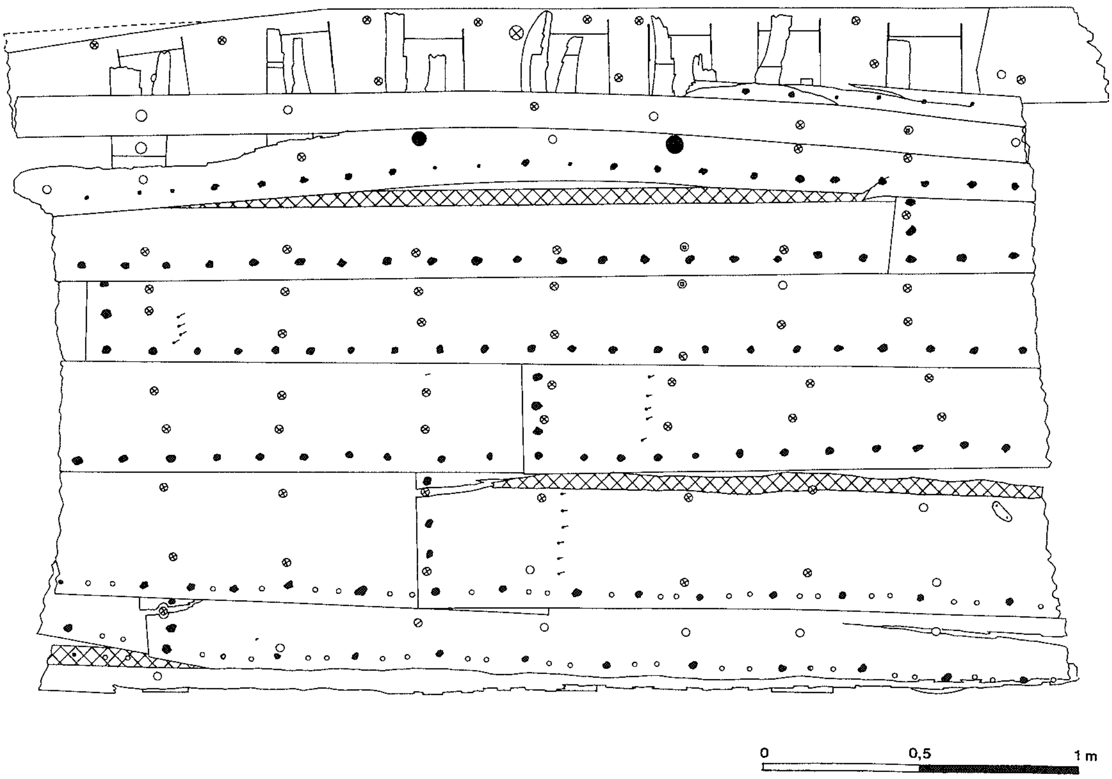

Fig. 44.6. Preserved part of the starboard side of the ship found at lot NE 159 in the Noordoostpolder, showing the alternation of two treenails and a rove and rivet.

ship	**dendro-date**	**strake-fastening**	**caulking**	**provenance wood**	**Cargo**
Rotterdam, boat 1	1252–1263	rove/rivet	moss	Lower Saxony (coastal area)	bricks
NG 35	1422±6	rove/rivet	hair/wool	Low Countries/Westphalia	oats
NE 159	1506±6	rove/rivet and treenails	moss	Low Countries/Westphalia and Southern Sweden	?
OU 34	1528 (+9/–6)	rove/rivet and treenails	moss[7]	South-east Poland and Baltic	?/Cargo floor
OM 11	1531–1533	rove/rivet and treenails	moss	Low Countries	Herring (barrels) Lead ingots Golfclubs (Grain)
NO 28	1530–1541	rove/rivet	hair	Baltic/Poland	?/Cargo floor
NJ 137	1540–1546	rove/rivet (bent nail)	hair	Southern Sweden	Grain/Cargo floor
NB 36	–	rove/rivet	moss	–	?

Table 44.1. Various attributes of the ship-finds discussed in the text.

fragment of the side was sawn from the hull and kept, luckily enough including the turn of the bilge, to determine that the transition strake was connected by rove and rivet, alternating with two treenails (Fig. 44.6).

The information about each ship is summarized in Table 44.1 and new elements added, that will be successively treated below.

From the dendro-dates it is clear that there is one group dating to the first half of the 16th century and two earlier ships, much more separated in time. The rove/rivet and treenail fastening is restricted to the first half of the 16th century.

The first attribute to be added is the kind of caulking material in the seams. The caulking material consists of moss and hair. Hair is typical for Great-Britain, Scandinavia and the eastern part of the Southern Baltic coast. Moss was used in the Rhine-Basin (including the Low Countries) and the western part of the southern Baltic coast. So from the material used for caulking, it can be concluded that the ships caulked with hair, are definitely not Dutch.

Another element which could shed more light on the provenance of the ships is the source of the wood supply. The provenance of the wood from *Rotterdam, boat 1*, is the coastal area of Lower Saxony. This might indicate that the ship was built there. Ole Crumlin-Pedersen (written communication) suggested to look for comparable finds in Britain. The slowly raking beam which connects the keel and the stern, shows a faint resemblance with the Graveney-boat, published by Fenwick (1978). The use of moss for caulking and the provenance of the wood make it however less likely that the ship was built in England. These same arguments, the absence of *bitr* and the spacing of the ribs (half of that of ships of the Nordic tradition) exclude a provenance of the ship somewhere in the North of Europe. Is it possible then, that this ship is a product or remnant of a postulated (yet unknown) Saxon style of boatbuilding that survived somewhere along the southern North Sea coast (van Holk, in press b)? This would explain the Anglo-Saxon connection. When the provenance of the wood to build the ship is an indication for the provenance of the ship itself, the repair in cog-tradition becomes less of a contradiction: the coastal area of Lower Saxony (wood-provenance) and the Rhine-estuary are bordering on each other.

Another surprising outcome of this table is, that the wood of three ships is dated by Dutch and Westphalian curves, while at the same time the fastening of the strakes and/or luting seem not native to the Low Countries. A good example is the ship found at lot NG 35: fastening and luting seem not domestic to the Low Countries. The trees, however, used to build the ship seem to have grown there or in neighbouring Westphalia. It is not to be expected that wood is imported into areas with a sufficient supply of wood, *i.c.* the areas where rivetting and hair-luting are indiginous. So we are left with two options: either rivetting was practised in the northern Netherlands and maybe also northern Germany, along the Northsea coast. This would however mean that the current picture of use of hooked nails in the Netherlands and northern Germany has to be revised. It is possible that along the Northsea coast a tradition of rivetting survived, dating back to as far as the Early Middle ages. Finds of roves and rivets from this period have emerged recently in so-called *terpen* (artificial dwelling mounds) in the coastal zone of the Northern Netherlands (Knol, 1993: 189; Knol *et al.*, 1996; Gerrets, 1999: 336). The question is of course: was rivetting employed by 'local' shipwrights or are the roves and rivets re-used specimen from foreign ships that wrecked in the area? The excavation of the terp Wijnaldum-Tjitsma showed that it was abandoned between the 4th and early 5th century; moreover a new material culture emerged after that period. The presence of roves and rivets would indeed support the idea of new inhabitants that originate in the eastern North Sea region, but the migration/acculturation debate is not yet solved (Gerrets, 1999: 337–338).

Possibility two is far less exciting; it might be the case that a dendrochronological problem is at stake, related to a data shortage of reference chronologies of a truly regional nature. So the provenance of the ship has to stay unclear, until further research has been done.

Still, an even more peculiar situation is possible: the ship found at lot NE 159 is built, again, from trees from the Low Countries or Westphalia, and at the same time trees from southern Sweden are used. Here again further dendrochronological research might be needed. Moreover, to answer the kind of question of provenance of the wood, one to three samples per ship is too little.

The same goes for ship OM 11: the wood originates from the Netherlands, whereas the fastening of the strakes might not be employed there. It should be considered, however, that the standard curves of the Netherlands and Westphalia might contain Baltic timber, which was imported at that time. It stays unclear in that case, why the samples do not show a closer correlation to standard curves from that area. Clearly this is a dendrochronological problem that needs to be scrutinized more closely.

The data from the big ship OU 34 fit more nicely

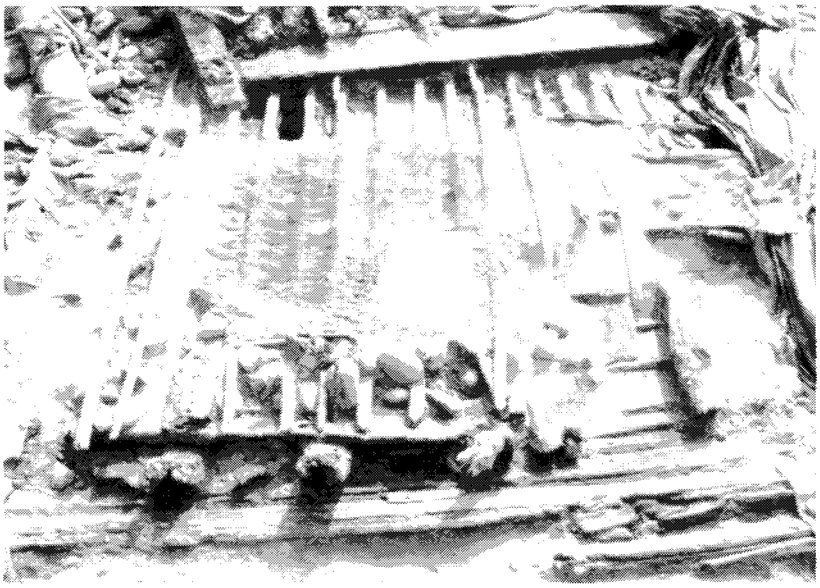

Fig. 44.7. The cargo floor of ship found at lot OU 34 in Oostelijk Flevoland, composed of a transverse rafter, a plaiting, a thick layer of sand and stones.

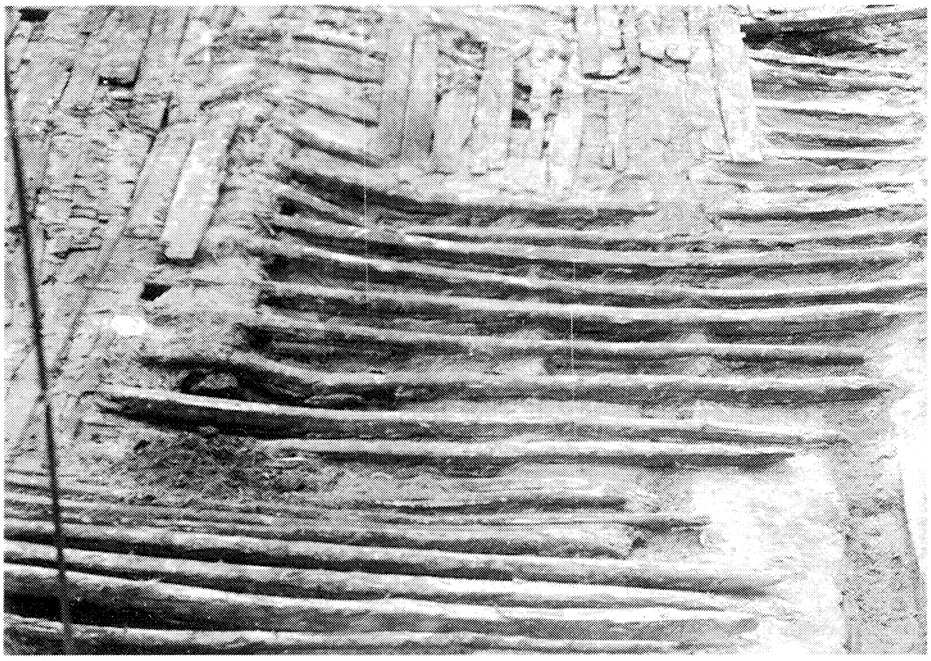

Fig. 44.8. Cargo floor of the ship found at lot NO 28 in the Noordoostpolder, consisting of a transverse rafter, barrelstaves, a plaiting and sand.

together. Fastening, caulking and origin of the wood in Poland form a congruent picture.

The second two ships (NO 28 and NJ 137) also show a plausible combination of technique and wood provenance. Moreover, both these ships have frames in the back, which resemble the *'bitr'* of the Nordic shipbuilding tradition. So both ships could have their origin in Scandinavia.

Cargo

The next element to be introduced is the composition of the cargo. From Table 44.1 it becomes clear that bricks, oats, grain and variables, like herring, lead ingots and golfclubs were transported. Three ships are equipped with cargo floors.

The bricks of *Rotterdam boat 1* are not indicative for any trade route (outside the Netherlands).

The composition of the weeds in the cargo of oats in ship NG 35, could, in this case, not give a clue to the growing area of the oats, because none of the weeds has a restricted area of distribution.

The cargo floor of OU 34 is an elaborate one, built on top of the ceiling (Fig. 44.7). The floor consists of a transverse rafter, a plaiting, a thick layer of sand, and on top of that a floor of stones. It seems too elaborate for only keeping the cargo dry. It may have functioned as a floor for animals: horses or cattle. The artefactual inventory of the ship indicates that she might have functioned as a warship. Besides that, two holes in the side could be interpreted as gun ports. Moreover, the great number of shoes could point to a group of soldiers aboard. So the elaborate floor possibly has to do with the function as a warship.

The same kind of floor is found in ship NO 28. It consists of a transverse rafter, covered by barrelstaves, a plaiting and sand (Fig. 44.8). Such a floor could have functioned to keep the cargo, such as grain, dry. On the inneride of one of the planks, impressions of corn and cornstalks could indeed be seen in the tarred spots.

The same situation holds for the ship found at lot NJ 137. The floor is somewhat different, but the principle is the same. Again a plaiting on top of the rafter is used to secure the cargo and keep it from becoming wet (Fig. 44.9).

During the excavation remains of grain have been found between the floors, so the interpretation as a cargo floor for grain seems likely for both the ships NJ 137 and NO 28.

So these ships were probably active in the grain trade. Already at that time, well before the booming grain trade of the 17th century, the Baltic was exporting grain (from Denmark and Poland). In this case construction provenance of the wood and cargo show a nice fit.

The OM 11 is a completely different story. What was left of the cargo, consists of herring in barrels, lead ingots and golf clubs (at that time golf was already a popular Dutch sport, right now becoming more popular still: you can not go walk on a meadow without stumbling over a green). Between the floors the remnants of grain were found. Herring, lead and grain again point to the Baltic. The same can not be said, however, about the golf clubs.

When we overview the finds there is a strong tendency towards the Baltic as an area of origin. Puzzling are some of the dendro-results on the provenance of the wood in the Low Countries, although this could just as well mean the Baltic. But still the possibility has to be considered that rivetting was also practised along the North Sea coasts of both The Low Countries and Germany. Further dendrochronological investigations and maybe ship-finds especially from the area, could give a clue.

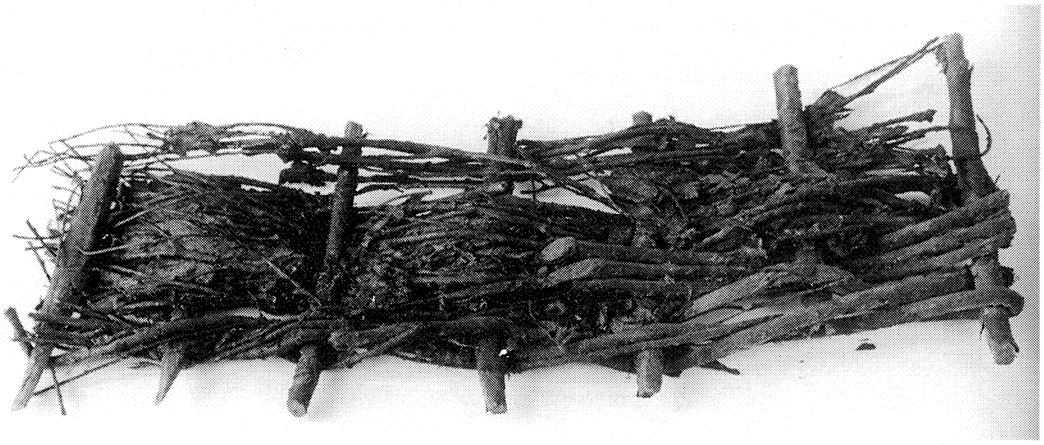

Fig. 44.9. A piece of plaiting from ship NJ 137 found in the Noordoostpolder (photo: L. van Dijk, Rijksdienst voor de IJsselmeerpolders).

Discussion and conclusion

Now let's go back to the model: clenched nails, treenails and hooked nails to connect the strakes.

It seems clear that we have to refine this model and add a new variant.

The three ships with rove-rivet and treenails to connect the strakes, show that only the bottom and the transition strake and the lowest strake of the sides are fastened that way. The pattern in which clenched nails and treenails alternate is very regular: every two or three treenails (depending on the ship) are separated by a clenched nail. Probably treenails were only used below the waterline, because they could expand there to form a strong fastening.

At first glance the combination of rove/rivet and treenails might mean a mix of two different building traditions, but maybe it is more fruitfull to look at this mix as a variant of the Nordic clinker-technique. In that case one could look at this type of fastening from a technological or economical angle and not so much from the viewpoint of ship-building traditions. The use of treenails instead of iron-clenched nails implies the use of less iron, so scarcity of the raw material could be at stake. Another possibility might be the higher efficiency (both in time and people) of the use of treenails: the fastening with treenails seems to be much faster in terms of building-time needed. A possible explanation is that a lot of ships had to be built in a short time span, due to a booming economy (as was the case in Poland at that time).

To sum up, the clenched lap-strake ship-finds from the Netherlands show:

- *Rotterdam boat 1* might be of Saxon origin or a remnant of that postulated tradition;
- the strakes of three ships are fastened by a combination of techniques: rove and rivet and treenails;
- these ships have a very close range in their dating;
- the provenance of the wood in the Netherlands or Westphalia does not seem to make sense, unless an ongoing rove and rivet tradition existed along the Northsea coast of the Low Countries and Germany.

Finally the finds will be put in a broader context. It is evident that ships from the Baltic and elsewere have visited the Netherlands for a long period, that started already in the 5th to 8th centuries, as the finds of roves and rivets in dwelling mounts, in the northern part of the Netherlands show (again under the assumption that roves and rivets belong to a foreign tradition!).

Maritime activity during the haydays of the Hanseatic League (1200–1400) is documented archaeologically by an ever growing amount of vessels of a known type: the cogs. In the IJsselmeerpolders lots of vessels have been found which could be identified as cog-like. A dissertation on these finds is being prepared by Vlierman from the NISA.

We know, at least from historical and iconographical sources, that from the end of the 16th century the flute became the most important and very successful sea-going trader. It is surprising to note that this ship-type is hardly documented in archaeological terms; this gap is filled by the paper of Manders, also from the NISA, on the excavation of a flute-like ship (see elsewhere in this volume). Still we are stuck with a period of which we know very little in terms of shipping: roughly the period between 1400 and 1600.

One might consider this period, from a Dutch point of view, as a gap. It is interesting to see that this gap was probably filled with ships of a foreign, probably Baltic, signature.

If this is true, one could look at the Zuiderzee as a trap, not of fish alone, but also of ships, in which trends in the shifting of centres of economic power are reflected.

Still there remain many questions, to be answered, which the present information may hopefully help to solve. Moreover, these finds deserve a closer examination in the context of an European project.

Notes

[1] Ring, Amersfoort, the Netherlands (E. Hanraets en P. van Rijn).

[2] Ring, Amersfoort, the Netherlands (E. Hanraets).

[3] Ring, Amersfoort, The Netherlands (E. Hanraets).

[4] Ring, Amersfoort, the Netherlands (P. van Rijn and E. Hanraets).

[5] Ring, Amersfoort, the Netherlands (E. Jansma and E. Hanraets)

[6] Ring, Amersfoort, The Netherlands (E. Hanraets)

[7] The bottom and bilge-strake are caulked with moss, moss-lath and cramps.

[8] The bottom and bilge-strake are caulked with moss, moss-lath and cramps.

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45. Illuminating Ships: Integrating the Evidence from Images and Materials in Medieval Europe

Joe Flatman

Introduction

Despite over a century of inquiry, it remains a depressing fact that the current knowledge of medieval vessels is slim. This paper uses a series of case studies to explore one way to improve this position: the integrated analysis of the archaeological remains of northern European medieval vessels with depictions of these in illuminated manuscripts. The central hypothesis proposed is that a meaningful relationship can be established between the one form of material culture that survives as a medieval image, and the other as an observable archaeological reality, through the use of much larger data sets than previously employed. As much concerned with the methodology of this process as the actual results, this includes exploring new ways in which such data can be approached, particularly definitions of vessel types based on their profiles, potentially more suitable for comparison with medieval imagery.

The basic principle of correlating different forms of data in this way has long been recognised: recent examples include Piponnier & Mane (1997), Jaritz (1995), and Duby (1999). The authors of many works upon medieval vessels also mention the concept (*i.e.* Hutchinson, 1994; Friel, 1995), several reviewing the relative merits of their sources, particularly Villain-Gandossi (1985a; 1985b; 1994). Few maritime archaeologists, however, have ever attempted correlations on anything but a one-to-one basis, the best example of this being Fenwick (1978). What has not been undertaken so far are large-scale cumulative and comparative studies designed to enhance the likelihood of such correlations having relevance. Starting from a large (600+ finds) archaeological data set, and moving from this towards many thousands of images only where suitable (Tilley, Fenwick, 1980), both of these sources are then analysed simultaneously. In such a situation at least a proportion of images and archaeological remains should always interconnect with one-another. Combining images and archaeological remains in this way represents one potential route towards more synchronous analyses of all the available data for medieval vessels, an approach that needs to be explored.

The Cog-type Vessel

Studies of cogs and their imagery have a long history (Weski, 1999a, 1999b; Greenhill, 2000), principally dating back to the 1950s onwards, when a number of scholars noted numerous images of a distinctive vessel type (*i.e.* Heinsius, 1956; Crumlin-Pedersen, 1965; Waskoenig, 1969). Suspected to be 'cogs' (a name derived from iconographic and historical sources), until the discovery of the vessel from Bremen (Abel *et al.*, 1969), no archaeological example of the type had been recognised. This often led to the distinctive features of the vessels depicted in the iconography being dismissed as overly stylised. The Bremen find forced a radical re-think after its lines were fully appraised (Heinsius, 1956), demonstrating that, in the integration of these different sources, the sum was greater than the individual parts, for the distinctive, angular hull lines were real, a response to a series of very specific socio-cultural demands fulfilled within technological and operational constraints.

In this particular case, the images and the archaeological remains could thus be seen to work together to identify a specific vessel type, perhaps the first time this had occurred. Consequently, the discovery of the Bremen cog is central to how all images and archaeological remains of vessels are analysed and integrated. However, the Bremen find may in the long term have caused as many problems as it solved. Because of its key role in identifying the vessel type, it was increasingly cited as the cog 'archetype': that is, if people wanted an example of a cog, they tended to point to the Bremen find alone. In fact, other cog-like vessels that were similar to the Bremen vessel – but not quite the same – have long been known. Some appear to be in the 'Nordic' tradition (Crumlin-Pedersen, 2000), others similar to the hypothesised 'hulc'

(Greenhill, 2000), and more still unique variants, small-craft versions, etc.

What is significant about the evidence from illuminated manuscripts is that these broadly support the complex debate for such variation within the overall 'type', a debate prompted by reanalyses of existing archaeological data (Weski, 1999a, 1999b; Crumlin-Pedersen, 2000). Examples include craft with the apparent attributes of both the cog- and Nordic- traditions, such as John Rylands Library, Manchester, MS Fr. 1, f. 226, and British Library, London MSS Eg. 1894, f. 4 and Roy. 14 E III, f. 153v (Alexander, 1992: 115, figs. 194, 195; Backhouse, 1997: 126). These correlate well with archaeological evidence from vessels like the Gedesby ship (Crumlin-Pedersen, 2000: 242). Then there are images that do appear to correspond more closely with the archaeological evidence for the Bremen cog, such as the vessels in British Library, London MS Roy. 10 E IV, f. 19 (Hutchinson, 1994: 155, fig. 9.5). Then again, craft with both cog- and some carrack-like characteristics can perhaps be identified: Bodleian Library, Oxford MS Bod. 264. 3, f. 218 (Fig. 45.1) depicts both Mediterranean 'galleys' and cog-like vessels, a virtually unique case of northern and southern European shipbuilding traditions depicted simultaneously. The vessels within it may represent something of the early merging of these northern and southern schools of shipbuilding that led to so-called coche – Mediterranean evolutions of the basic cog form. A number of other variations also then appear to be visible within both forms of evidence.

The division of imagery presented above is clearly an oversimplification that can be criticised. And it is indeed true that the real situation is not so simple. However, for the sake of argument, the identification of different vessel types in this way is both useful and significant, demonstrating how images may be capable of supporting developing archaeological theories about variation, and reflecting some of the subtly different forms this can take. Even if the real situation is more complex, therefore, the case of the cog is thus a very good example of both how images inform our understanding of vessel types, and also how integrating images and archaeological remains is viable and valuable.

The Mary Rose

The carrack Mary Rose (Rule, 1983), and also the famous depiction of the vessel in the Anthony Roll (Magdalene Coll., Cambridge, Pepys Library MS 2991, p. 6) (Knighton, Loades, 2000: 42–43), represent a unique example of an archaeological find identified as the remains of a specific vessel, for which there is a near-contemporary illustration. However, just as the Bremen find may have focused attention onto a specific form of the cog tradition, so the Anthony Roll may have focused attention onto a specific vision of the Mary Rose that bears little relation to archaeological reality. Due to the Anthony Roll's fame, while there is undoubtedly much to be learnt from this manuscript, it potentially clouds our perspective of other manuscript illuminations of this type of vessel that may be of equal or greater value. The manuscript was clearly also deliberately stylised for political and symbolic purposes. Consequently, these factors seriously reduce its technological value at least, as confirmed by research showing the Mary Rose to have been quite different to the ship depicted (Vine, 2000: 15–16). Slightly later manuscripts such as Baker's Fragments of Ancient English Shipwrightry (Magdalene Coll. Cambridge, Pepys Library MS 2820) are thus probably more useful for such direct comparisons of the overall hull form at least (McKee, 1972: 244, fig. 14), if not for specific vessel components. Many other useful manuscript comparisons from earlier periods then also exist.

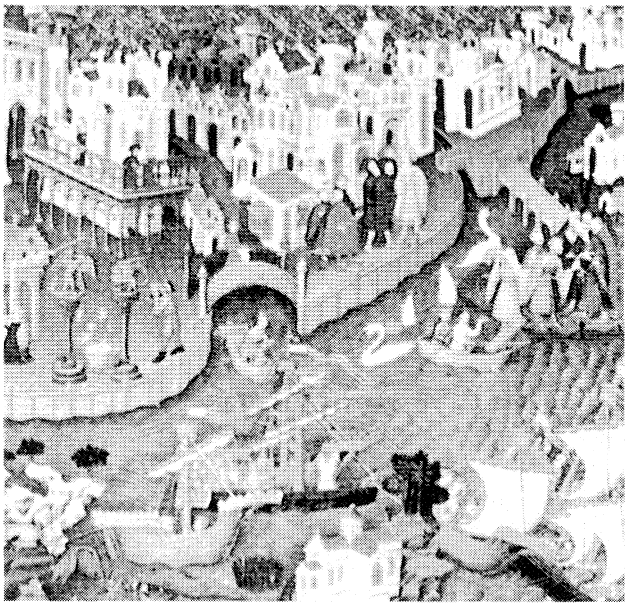

Fig. 45.1. MS Bod. 264.3, f. 218 (by permission of the Bodleian Library, Oxford).

However, if in general the physical evidence suggests the Anthony Roll is not a totally accurate representation of the vessel's overall hull, new research also demonstrates that some of its details are extremely accurate. For instance, there is archaeological evidence for the three semicircular ports depicted in the waist, the series of vertical blinds above them, and the anti-boarding netting above these. Then, at the very top of the mainmast a very small 'fighting' top is depicted, also very similar to one recovered from the wreck (Vine, 2000: 15–16). The case of the Mary Rose is thus quite a different example to that of the cog, raising a number of debates as regards the interaction of images and archaeological remains. It also illustrates that, while images can misinform the understanding of whole vessel types, this does not preclude their including very accurate specific details within this.

The Sandwich Ship

The archaeological assemblage known as the Sandwich ship – under analysis by a team led by Gustav Milne of the Institute of Archaeology, University College London – comprises of *circa*25 elements of a large vessel originally recovered from Sandwich, Kent (Trussler, 1974), now curated by Dover Museums Service. It includes various diagnostic fragments such as a median rudder, parts of the sternpost, several frame elements joggled for clinker planks, and two Y-shaped frames from above the 'deadwood' section at the stern. These are enough to suggest that the vessel was originally over 30m long, at least 4m high, clinker-built, robustly framed, sharp-ended and decked. Dendrochronological analyses suggest a late 14th or early 15th century felling date for the timber, and a source in SE England (Milne, in press).

What is particularly significant about this vessel is that it may represent a specific northern European style of shipbuilding prior to the main surge of Mediterranean shipbuilding influence in the north (Hutchinson, 1994: 32–34). If so, the remains are very important for the study of later medieval ship construction. But the archaeological evidence alone is insufficient to create a full picture of what the vessel may have looked like. A careful comparison of the archaeological data with a wide range of images is thus potentially very fruitful, and a number of suitable manuscript comparisons do exist. For example, British Library, London MS Add. 42130, f. 161v (Hutchinson, 1994: 54, fig. 3.4) shows a vessel with a similar type of hull shape and structure. British Library, London MS Harl. 4418, f. 80v then includes vessels in the background that are good examples of the likely hull shape and stern assembly, and vessels in the foreground that are good examples of the type of clinker-built hull the Sandwich ship would have had (Fig. 45.2). There are also a number of images containing vessels with useful details, but which include specific elements that throw doubt on their suitability for comparison with the whole vessel. For instance, Bodleian Library, Oxford, MS Douce 353, f. 31 (Fig. 45.3) shows a vessel accurate in terms of size and its use of decking, but which is probably carvel rather than clinker planked. Similarly, the vessels in folio 207 of British Library, London MS Roy. 15 E vi (Porter, 1999: 39) have good general features, but are smaller than the Sandwich ship would have been. Many other examples can then be called upon in similar ways.

This final case study is thus an excellent example of how images can help archaeology take a step further than it could on its own, and how large databases can be of particular assistance. Integrated together, these two forms of evidence allow a series of hypotheses to be built that suggest both how such a vessel may have been built, and also what it may have looked like.

Conclusion

Folio 218 of the 15th century Li Livres du Graunt Caam (Bodleian Library, Oxford MS Bod. 264.3) (Fig. 45.1), is

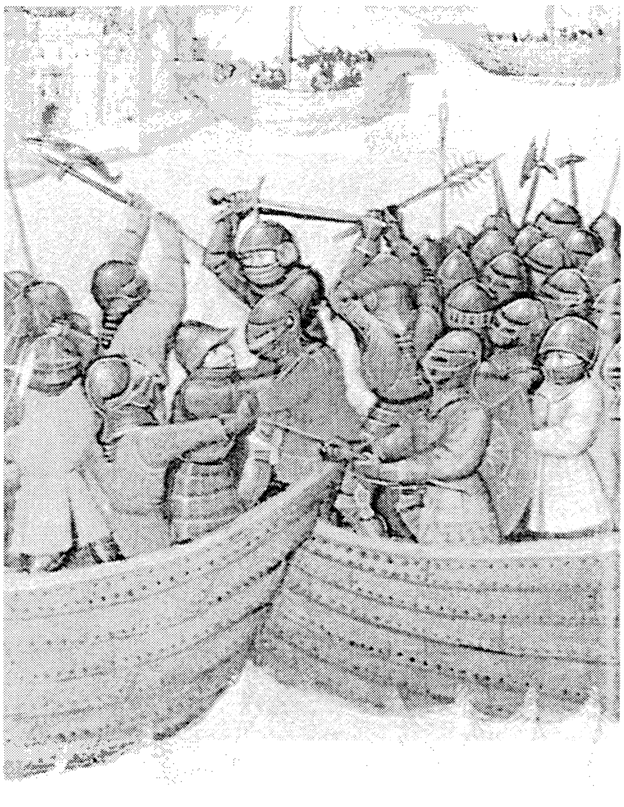
Fig. 45.2. MS Harl. 4418, f. 80v (by permission of the British Library, London).

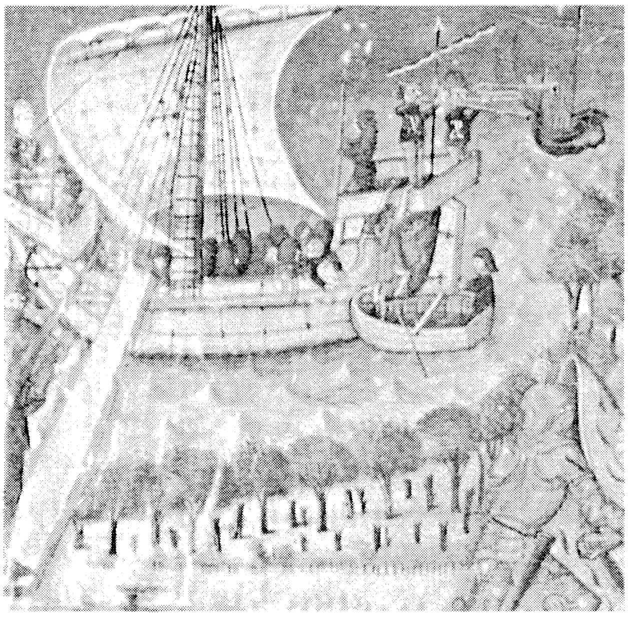
Fig. 45.3. MS Douce 353, f. 31 (by permission of the Bodleian Library, Oxford).

a unique example of vessels of both the northern and southern European shipbuilding traditions depicted simultaneously while moored off Venice. In a series of edited papers from a conference held in Venice on the eve of the millennium, an image of that city that so succinctly draws together the different vessel traditions of medieval northern and southern Europe seems an appropriate place to end. Furthermore, this image sums up this entire field of research, not only depicting different types of vessel and their many hull details, but also the surrounding 'maritime cultural landscape' (Westerdahl, 1992), making it clear that manuscript illuminations can inform more widely than simply upon vessel types and traditions alone: they can expand our entire view of the ancient world. Referenced to other forms of medieval data, such images then provide a tangible demonstration of the benefits of comparing large data-sets, as well as a better understanding of the technological accuracy of medieval manuscript illuminations, a greater appreciation of how such images reflect deeper cultural trends, and an improved comprehension of how images and archaeological remains can be integrated.

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46. Squares and Stripes: Remarks about Textiles Archaeology and Sails[1]

Susan Möller-Wiering

Introduction

The so called Hedeby coins (Malmer, 1966; Crumlin-Pedersen, 1997: 172–176; Steen Jensen *et al.*, 2000) were found in different places in Scandinavia but are said to be all coined during the early 9th century in southern Denmark, *i.e.* in Hedeby or perhaps Ribe (Fig. 46.1). Some of the depicted ships are equipped with sails in criss-cross pattern, thus resembling the usually older Gotland picture stones (see Lindqvist, 1941; 1942). However, the majority are divided by vertical lines – a feature unknown from Gotland. Taking the perspective of an archaeologist specialized in textiles, we have the temptation to find an explanation for this difference in the characteristics of the sails themselves, *i.e.* the textiles. As the interpretation of the depicted hulls has been undertaken very seriously (Ellmers, 1972; Crumlin-Pedersen, 1997: 174–176), it seems reasonable to propose the sails as an information-bearing source as well.

Typical elements of sails in art

A look back in time reveals that starting with the early representations in the Eastern Mediterranean, the artists avoided leaving the sails plain und uniform (see *e.g.* DeVries, 1972: 42, fig. 3 and 43, fig. 8; Van de Moortel, 1994; Gifford *et al.*, 1997: 203). Reliefs of Roman times

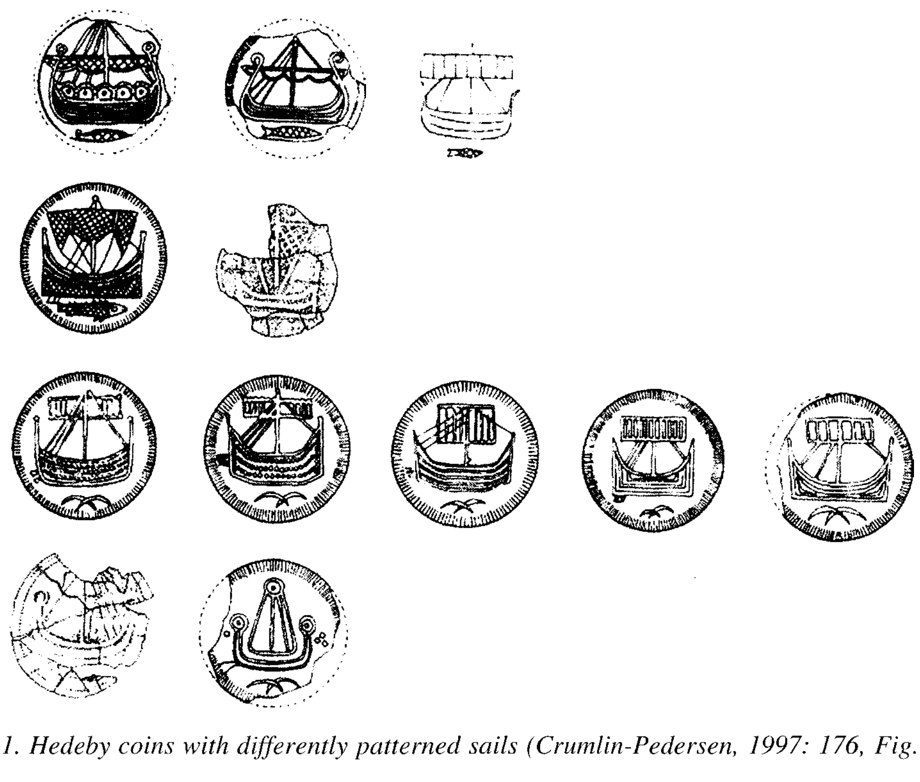

Fig. 46.1. Hedeby coins with differently patterned sails (Crumlin-Pedersen, 1997: 176, Fig. 7.10)

which are generally accepted as being close to reality (Villain-Gandossi, 1979: 223) usually depict square patterned sails. The pattern is the result of horizontal reinforcements or reinforced seams and vertical ropes, supplemented by rings on their crossing (Roberts, 1987: 88; Pferdehirt, 1995: 10). A good example is the well-known Torlonia relief from Portus, dated to the 2nd century AD (Throckmorton, 1972; Pferdehirt, 1995: 10). However, there the ropes should run across the sail's decoration and some rings are set aside because of it, so realism is somewhat adjusted to the artist's ideas.

Medieval art seems to be less realistic, though the principle is the same. There are *e. g.* several sails with reef points spread all over: the reef points' number as well as their arrangement are incorrect, but still they represent a realistic feature (see *e. g.* Brindley, 1912: 241; Clissold, 1973: 461). Sometimes they are given an unusual colour which was – besides multiplication and exaggeration – another common means of emphasizing a detail (Villain-Gandossi, 1979: 223). This applies *e. g.* to a miniature dating around 1200 with many red serpentine reef-points (Crumlin-Pedersen, 1972: 196, fig. 12). Being something new at that time,[2] this feature seems to have fascinated the painter.

The artists' choice of elements to fill the sails' surface certainly depended on art traditions as well as on the medium in question – a miniature offers wider possibilities than a coin. But it also depended on the real sails of the time and their features. It seems that the striking and perhaps especially the new characteristics were preferably chosen as a kind of an eye-catcher. As this applies to representations of different times and different regions, it might be proposed that this is true for the sails on Hedeby coins and Gotland picture stones as well.

Sails with squares

It was suggested that the squares on sails to be seen on the Gotland picture stones might represent small pieces of cloth sewn together (Lindqvist, 1941: 71) – as was later proposed for a sail on a Greek vase of *ca.* 700 BC (DeVries, 1972: 42, fig. 3) – and that the demand for sail cloth might have initiated the production of long cloth panels in Scandinavia (Andersen, 1997: 209). But already from the 6th century BC onward there are Greek representations of warp weighted looms with revolving beams to roll up the cloth (Barber, 1992: 72, fig. 2.38, and 108, fig. 3.25 and 3.26; Stærmose Nielsen, 1999: 70, figs. 37–38, 40–41, 74–75), so panels of several metres length could easily be woven. It is not impossible that such looms were already in use when the above mentioned vase was painted meaning that there might be a different explanation for the squares on that Greek sail and other examples from the Aegaean.

There is no reason to believe that such a simple equipment like a revolving beam remained unknown in the north though it is not yet known when it was introduced. But woollen cloaks like from Thorsberg, dating to the Roman iron age and woven on warp weighted looms, are 2 to 3 m long (Munksgaard, 1974: 132; Schlabow, 1976: 63), thus indicating the use of the revolving beam. The warp weighted loom remained common until the end of the Viking age. At the same time the tubular loom was being used. Woollen cloths of over 3 m length were produced on such gear already in the Bronze Age or early Iron Age (Hald, 1980: 173, 187). So no matter which type of loom was preferred by the Scandinavians to weave sail cloth it was no problem to manufacture it in long panels.[3] Using panels for sail making then means that the seams between the cloths were placed either vertically or perhaps horizontally, but not obliquely. So at least those squares that are arranged diagonally – like on the coins – must represent something else than pure seams and in all probability something more striking to the eye.

Several authors suggested reinforcements (Söderberg, 1967/68: 273–275; Svensson, 1984: 125), like in Roman times, and this might be the most probable. Since sails made of wool were common in Scandinavia (see Andersen *et al.*, 1989),[4] we may expect them on Gotland as well as in Hedeby. Wool is a very elastic material, so reinforcements to reduce elasticity may be very useful on woollen sails, especially if they were very big. And it must have been best to sew them onto the sail in a right angle relative to the seams or diagonally because the seams themselves already give strength to the sail which may be deduced from the fact that pseudo seams could be used on a sail to stabilize its shape (Berggren, 1972: 49).

Some passages in the saga literature point to the structure of sails and repeatedly the expression "stafat med vendi" is used (see Falk, 1912: 63). This term is supposed to refer to a rod (pers. comm. J. Görtzen) – *i. e.* to something long and thin – and/or to something sewn obliquely (Falk, 1912: 63). Obviously, this corresponds much better with narrow reinforcement strips than with broad panels. So when it is written in the Saga of Olav the Saint "The sail was as white as a snow-drift and coloured with a red and a blue strip",[5] this might rather refer to narrow, coloured strips on a plain white sail than to a sail made up of broad, coloured panels. The common idea of Viking sails with broad stripes in *e. g.* red and white might not necessarily be correct.

Finally, some textile fragments should be mentioned which were found in the Gokstad ship and interpreted as a sail (Christensen, 1979: 190). There, red strips are sewn onto a formerly white tissue, both being made of wool (Boehmer, 1893: 624, Ingstad, 1988: 135–136). To sum up, what can be found in different sources – iconographic as well as written evidence, the Gokstad find plus some considerations concerning textile production and wool characteristics – point into one direction: that, in all probability, the early Scandinavian sails had reinforcement strips which were sewn criss-cross and often served as colourful ornaments, too – so they were those eye-catchers that the artists picked.

Sometimes the squares on the Gotland stones are not indicated by lines but by a checkerboard pattern. Recalling exaggeration as a means of emphasis there is no contradiction between these two variations since the checkerboard pattern simply accentuates the impression of squares. Whether the same principle may apply to the early East Mediterranean depictions is not to be answered without further research. However, the similarities are striking.

Sails with vertical lines

But what about the other sails on the Hedeby coins, those that do not show such reinforcements? A possible explanation is that they were made of a different material which did not require any strips. An alternative may be linen which is much less elastic than wool. In the area south of Scandinavia, linen production was very common (Körber-Grohne, 1988: 372–373) and taking Roman traditions into account, linen sails should be expected there. Therefore linen sails may be expected on the pictorial sources of that region. Looking at these, it is easy to see that the sails are usually light in colour (see *e. g.* Grape, 1994: 35–36, figs. 19, 22) which fits well with the idea of linen. And they often are devided by vertical lines which are darker than the cloth (see *e. g.* Hutchinson, 1994: 12, fig. 1.5, and 54, fig. 3.4). The vertical lines quite obviously represent the seams between the panels. On an embroidery made in England around 1270, the seams are even marked stich by stich.[6] In this case the panels are coloured which is a feature that becomes more common from the 13th century onward (see *e.g.* Lindgren,1981: 140, fig. 5 and Hutchinson, 1994: 51, fig. 3.2). But early Central or West European pictorial sources showing a sail with squares seem to lack – even on the Bayeux tapestry where some Scandinavian influence may be suspected.

Conclusions and comparison

In other words, the Central European linen sails are identical with the majority of the sails on the Hedeby coins. Taking the close contacts between Hedeby and Frisia into account, and adding the fact that linen was also produced in the area of Hedeby – though perhaps not much (Behre, 1983: 24–26) –, it might be reasonable to interpret those sails with vertical lines as linen sails in contrast to the criss-crossed sails which represent the Scandinavian type made of wool and strengthened by narrow reinforcement strips. After all, the idea is quite simple: as a given raw material is combined with a certain way of sail making, the sails look different and are represented differently in the iconographic sources.

The same principle is to be found in the treatise *Fabrica di Galere* which originated in northern Italy in the 15th century (Bellabarba, 1988). The text includes a description how to make a sail: it should be manufactured mainly of fustian which is a mixture of linen and cotton, while the most stressed parts were made of hemp. And there should be vertical and horizontal reinforcements all over the sail. Following the description, there is a sketch of a ship whose sail seems to be made up of squares. Therefore one can be quite sure that these squares represent the reinforcements on a fustian sail. And as other representations of ships from the same time and area reveal the same pattern (Hutchinson, 1994: 41, fig. 2.10), it must be assumed that they were also equipped with fustian sails.

Since the research reported here is focussed on the northern and central parts of Europe it is impossible to say whether the early square and checkerboard patterned sails of the Mediterranean follow the same principle, thus representing reinforcements perhaps in combination with ropes. However, it does not seem likely that they were made up of small pieces of cloth. Further investigation is necessary but after all, it might be acceptable to postulate a meaning in squares and stripes on the representations of sails.

Notes

[1] This paper is based on the present author's dissertation (2002). However, this topic is not the main focus of the dissertation but rather a side product and should therefore be considered as a preliminary result.

[2] The seal of La Rochelle is of about the same date, but neither does Brindley (1920: 78) name older examples nor are there any among the material collected for the above mentioned dissertation (Möller-Wiering, 2002).

[3] For further arguments concerning the production of cloths of several metres length, see Möller-Wiering, 2002.

[4] For further examples and details see Möller-Wiering, 2002.

[5] "seglit var hvítt sem dript ok stafat rauðu ok blá með vendi" (after Falk, 1912: 63), translated by the author.

[6] Thomas Becket returning to England, embroidery, England, *ca.* 1270, Abegg-Stiftung Riggisberg/CH (postcard).

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47. Ships and Private Shipyards through the Archaeological Evidence of the Wreck off La Natière (Saint-Malo, Brittany, France)

Michel L'Hour, Elisabeth Veyrat

Introduction

La Natière shipwreck has been excavated since 1999. Although the title of this article seemed to point out a general talk about private shipyards in Saint-Malo, the *La Natière* site is so rich that the tracks offered by the first archaeological finds have just begun to be explored. Therefore, this paper will deal with the particular features of the site and of the artefacts which raise interesting questions related to the larger framework of ship construction and shipyards in Saint-Malo.

The *La Natière* site offers two main directions of research:

- firstly, the possibility of documenting and analysing the technical features of the ship's structure. This will allow a better understanding of the specific characteristics of the Saint-Malo private ship production at the end of the 17th century and the beginning of the 18th century;
- secondly, in a broader context, the possibility of analysing the archaeological data as remnants of the maritime material culture in north-western Europe;

This approach seems to be a paradox dealing both with specific questions and general themes. This is the reason why *La Natière* shipwreck is important for the progress in maritime archaeology, offering data for both approaches.

The project and the team

Saint-Malo, off the north coast of Brittany (Fig. 47.1), has been one of the most important centres of French maritime trade, from the 13th to the 18th century. By 1700, Saint-Malo had a main role in three major maritime activities : overseas trade, cod fishing and privateering.

The overseas trade with West and East Indies occurred especially through the Cape Horn route, from the French Atlantic coast to the Pacific coast of South America. Cod fishing in New-Foundland and Spitzsbergen, called "*la grande pêche*", involved fishing and sometimes settling on foreign coasts. But both these commercial enterprises were combined with privateering. This capturing of foreign vessels by the French ones was an independent activity, but usually, the same ships were involved in those three different activities, the two last ones requiring numerous men aboard.

Discovered in 1995 close to the city walls of the city of Saint-Malo, *La Natière* wreck, after a preliminary survey in 1996, is the object of an important archaeological project inaugurated by two campaigns in 1999 and 2000. The archaeological site covers a large area of almost 1000 m^2 as the ship remains are scattered over around m 50 in length and m 20 in width, at a depth varying from m 9 to 19 (Fig. 47.2).

According to the first two excavation campaigns, it is possible to identify two major areas of structural remains in the West and East sectors of the site, with an apparent sterile zone in the middle. This feature might be an

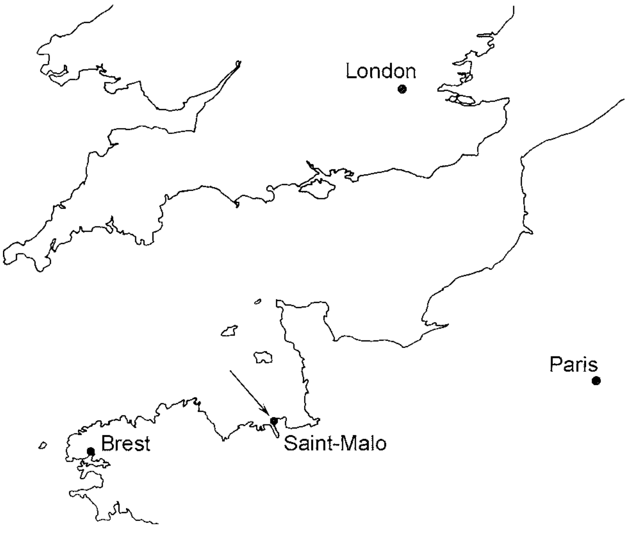

Fig. 47.1. General location of the site.

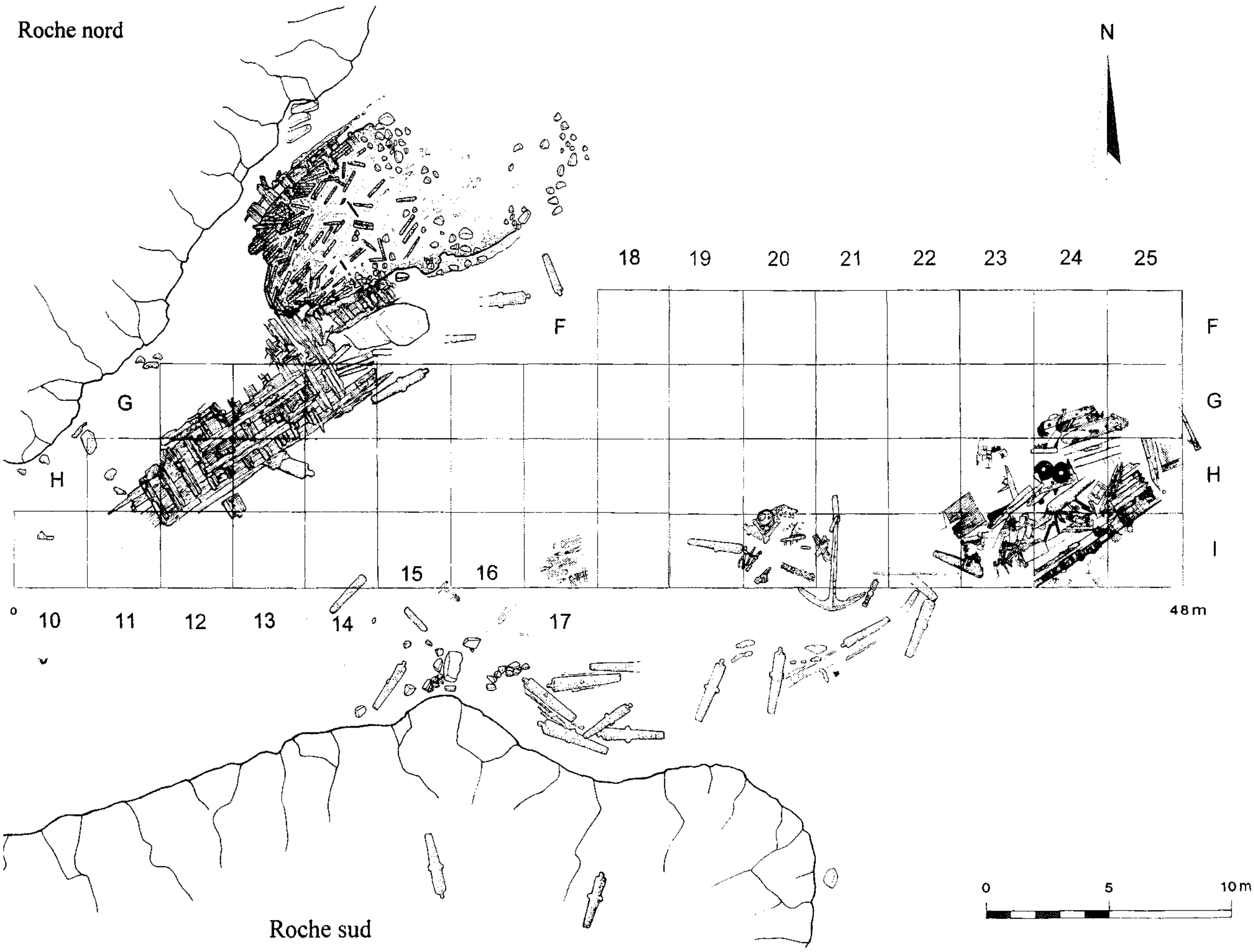

Fig. 47.2. General plan of the site.

indication that the site is not homogeneous, but consists of two armed merchant ships, built and equipped almost similarly and probably sunk only a few years apart. The next campaign of fieldwork might provide us with an answer to that question.

On the basis of artefact analysis, the wreck or two wrecks are dated between the end of the 17th century and the beginning of the 18th century. Also the finds indicate that the ship has a French origin.

Some of the most significant French artefacts are painted "faïence" pots from the Rouen workshops (north-west of Paris, see Fig. 47.9), bottles and large stoneware jars from Normandy, and small tripod pots and pitchers from Saintonge in the south-west of France. All these types of ceramic are very similar to those found on the *La Hougue* wrecks, five French men-of-war ships coming from Brest (see location on Fig. 47.1) and lost in 1692 off the Norman coast. There are also evident parallels with ceramic finds from land excavations in Saint-Malo.

The presence on the site of several arms, such as sabres, pistols, and about thirty cast iron guns of heterogeneous dimensions and swivel guns, substantiate the identification of a privateer ship. This hypothesis is also supported by archival evidence, as there are only rare records of losses of foreign ships. Furthermore, French warships seems to have suffered shipwreck off Saint-Malo in that period.

An important indication about the ship's last itinerary before its wrecking, is provided by the remains of a young macaque, less than 6 months old, probably from Gibraltar (*Macaca sylvanus*).

Identification of the ship

In the archival documents, about thirty wrecking incidents are mentioned near Saint-Malo between 1670 and 1743. Most probably the *La Natière* shipwreck is one of the local built ships on this list. Few data are available on shipbuilding in Saint-Malo during that period, therefore identification of such a vessel would be of great importance.

This period represents a turning point in Saint-Malo shipbuilding history. An inventory of Saint-Malo merchantmen from 1664 shows that the town is relying mainly on foreign shipbuilding, mostly Dutch. In fact, less than

1/4 of the trading fleet of Saint-Malo was of local production. At the end of the 17th century this situation changed. A special subsidy provided by the King gave a boost to the development of the Saint-Malo shipbuilding industry, with 80 percent of the fleet being built locally. After 1680, Saint-Malo produced ten to fifteen ships per year, and even more, twenty-five ships were built in 1704, varying from 30 ton boats to the 600 ton traders.

A special type of vessel developed in Saint Malo answering to the specific demands of the local ships owners was the frigate which combined high speed and good manœuvrability.

Unfortunately, there is a gap in our knowledge of private ship construction. So, the major goal of the *La Natière* project is to provide archaeological evidence and to contribute to this historical issue.

Saint-Malo shipyards

The study of the architectural remains of *La Natière* shipwreck is still in the preliminary stage and only limited portions of the wreck have been uncovered, in the eastern and western parts of the site. As a matter of fact, no coherent site plan of the overall ship's structure is available yet and furthermore, we have to keep in mind the possibility than the site contains two shipwrecks close to each other.

However, some clues might be already suggested about shipbuilding practices. The ship seems to have been built with great care, as, for example, in the way some filling pieces are carefully fitted and bevelled between floor-timbers, as well in eastern as western parts of the site (Fig. 47.3). Moreover, a first analysis of wood species of timbers, like floor-timbers and futtocks, shows that mainly coppiced wood was used. Dendrochronology analysis is currently underway and the presence of sapwood provides a good chance for a relatively close dating of the ship construction.

Although the complete hull structure is not mapped yet, the excavation has already provided a more detailed view of the ships equipment with a rich group of artefacts.

Some tools and materials found give information on the carpentry and caulking activities on board, as more than fifty blocks recovered, until now, most of them unused and brand new, stored in the hold of the carpenter. A large number of blocks with identical sizes were found stacked closely together near a large number of other related objects such as a pump upper box, belonging to the stock of spare parts, stored in the forward lockers of the ship. In other respect, utilisation of lime wood has been noticed for several block's axes, a practice which seems rather unusual for rigging wood species.

A set of caulking tools of about twenty scrappers, a mallet and other woodworking instruments, as a brace, have been found in the same area as the stock of rigging spare parts. Each of these tools brings back into memory the continuous care of seamen to keep the ship's hull watertight and dry, as for example some lead rolled strips called in French "*plomb en table*" (Fig. 47.4). Moreover, some square lead sheets, one square foot and already coated with oakum, were ready for general watertight works.

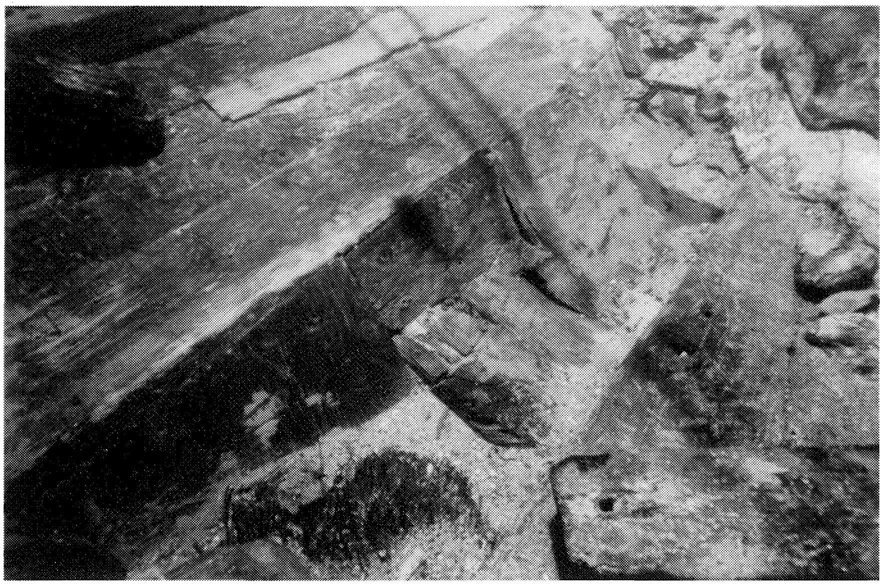

Fig. 47.3. Hull structure of the eastern part of the wrecksite, detail of inner planking and framework (photo: F. Osada).

Only scarce evidence of the decoration of the ship, as a carved wooden piece made of poplar, has been found (Fig. 47.5). This piece is probably coming from the gunwale of the ship. This functional adornment might be very common, either on merchant or on men-of-war ships, as shown on the famous engraving from the *Dictionnaire de la Marine à Voile, Encyclopédie Diderot d'Alembert* (Fig. 47.6).

While the study of the hull structure will contribute to a better understanding of the private shipbuilding in Saint-Malo, shedding light on some particular technical features,

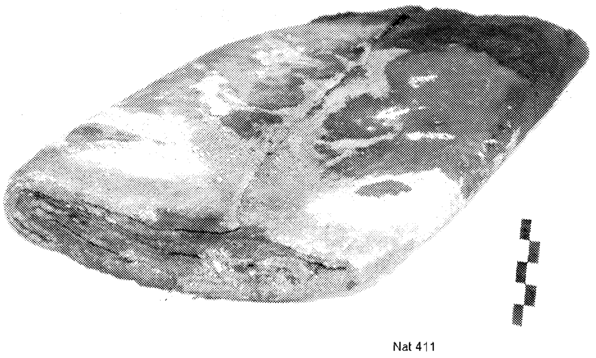

Fig. 47.4. A lead strip roll, one French foot large (Nat 411).

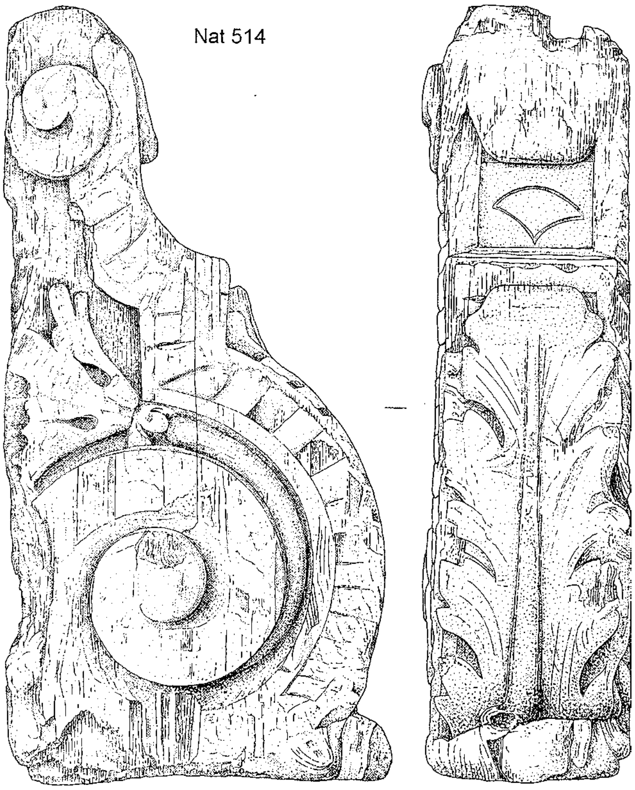

Fig. 47.5. Carved wooden piece (Nat 514) (drawing: M.N. Baudrand).

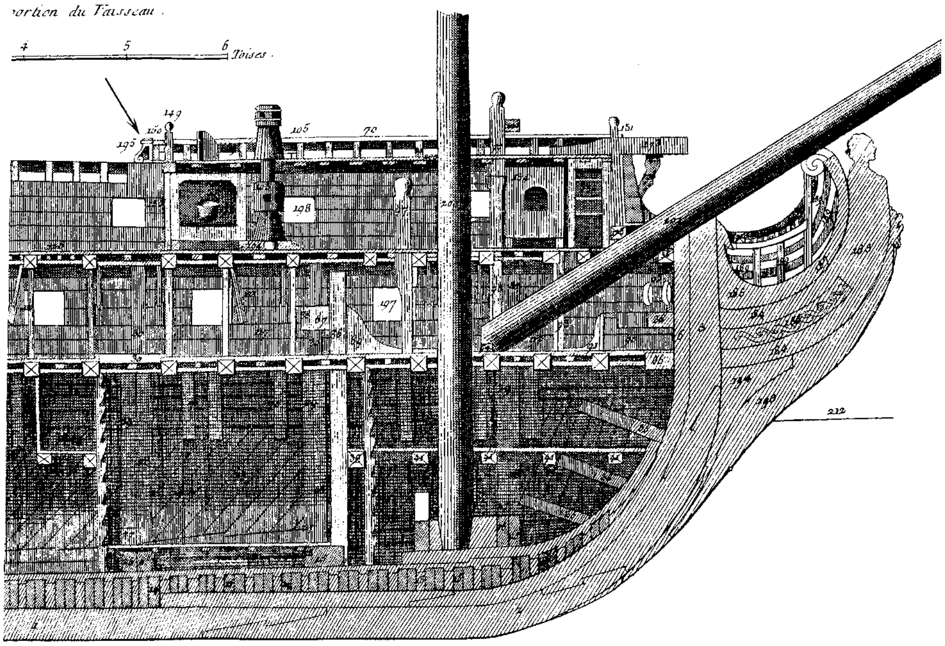

Fig. 47.6. Encyclopedie Methodique Marine, *by Diderot et d'Alembert: location of a carved wooden piece similar to the one found on the wrecksite of La Natiere.*

one can expect that the overall analysis of the wreck will help to define a global Atlantic maritime culture, directly related to the equipment of ships. In fact, comparison between the fitting of different ships of that period seems to go beyond regional particularism and to show a uniform picture for all north-western Europe.

In a period in which the privateers were contributing to the acceleration of exchanges by the capturing of cargoes, ships and naval equipment, a frigate like the one used in Saint-Malo would represent a point of convergence for European maritime culture in general.

A focus on some finds from *La Natière* might help to briefly illustrate the relations between different ports around 1700 where ships got their supplies.

For example, a long wooden rack, probably used for nails storage, looks very similar to the one found in the *La Hougue* site (Fig. 47.7). In fact, they are so identical that they seem to originate from the same material culture which could be specific to the maritime environment. Another example is provided by some round glazed

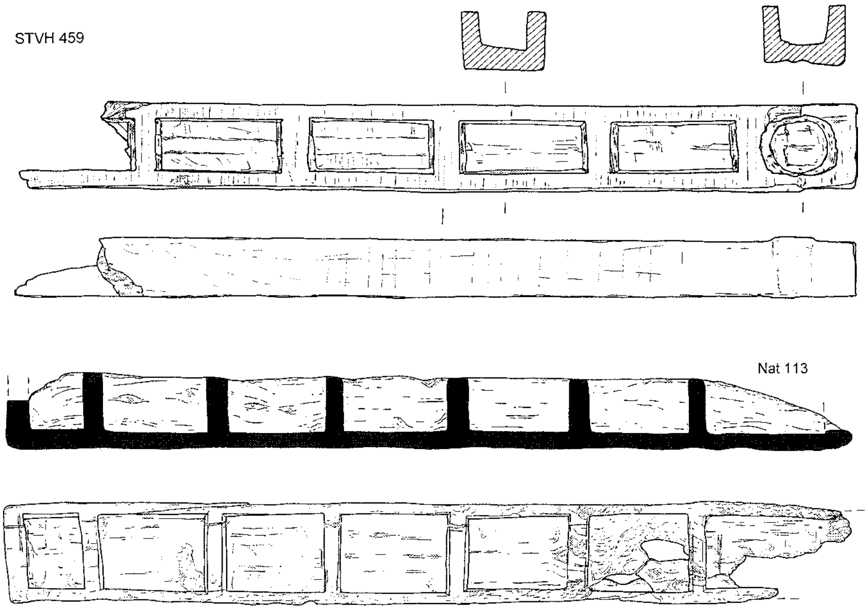

Fig. 47.7. Two wooden racks found in La Hougue *wrecksite (STVH 459) and* La Natiere *shipwreck (Nat 113) (1:8 scale).*

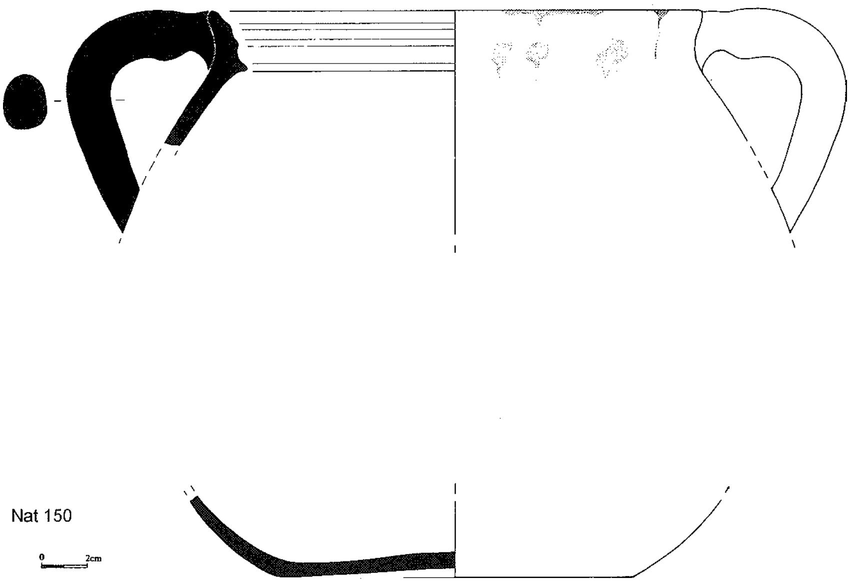

Fig. 47.8. Glazed cooking pot Nat 150.

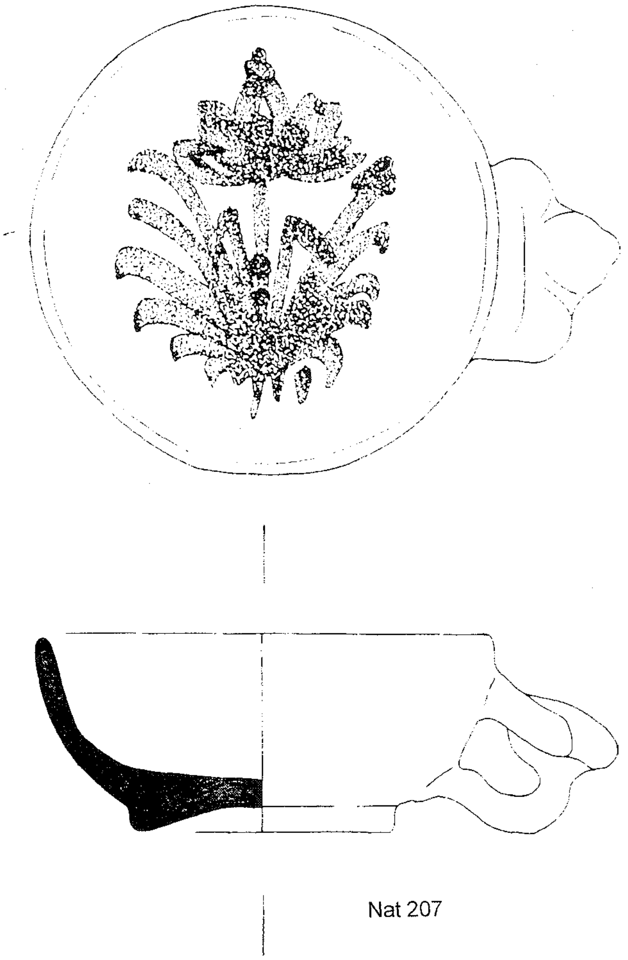

Fig. 47.9. Little white faience cup with blue pattern (Nat 207) (1:1 scale).

cooking pots (Fig. 47.8). Although the provenance of these ceramics is doubtful, they show very close similarities with those found on the *La Hougue* ships (1692), the privateer ship *Alcide* (1747) and on the frigate *Machault* (1760), excavated by Park Canada underwater service. In other respects, two blue and white faïence cups, with a rounded handle and a flat ear, are identical to several cups from *La Hougue* (Fig. 47.9). With no doubt, these objects come from the same supplier and answer similar needs.

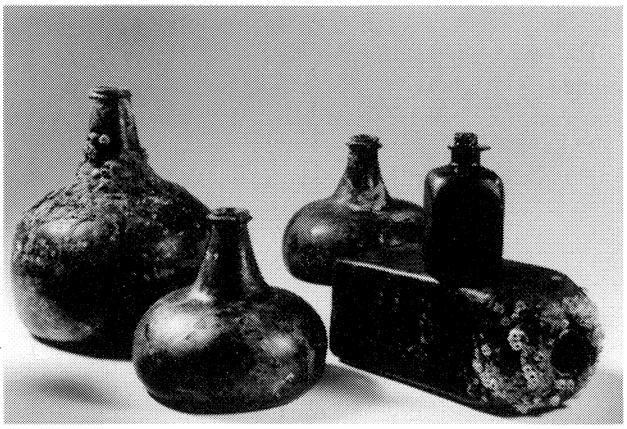

Fig. 47.10. English and Dutch bottles from the La Natiere *shipwreck (picture: F. Osada).*

Those few examples illustrate well a common supply organisation throughout the French maritime sphere for several vessels of different origins. But going further, one can argue that it is the same case for other general items found in the *La Natière* wreck from foreign origin, such as English and Dutch bottles (Fig. 47.10) or English clay pipes.

La Natière shipwreck is definitely a good example of what can be expected from Post-Medieval archaeology, combining archival and material sources. Although this excavation just started and will hopefully continue for several more years, we are convinced that this project can contribute to our knowledge on two main fields of research. Firstly pointing out the specificity of private shipyards of Saint-Malo by 1700. Secondly contributing to a *corpus* of information showing the existence of a true European maritime culture.

48. The Mysteries of a Baltic Trader

Martijn R. Manders

Christmas Eve 1593. More than a hundred ships are waiting on the roadstead Texel for the right wind to sail.

The night is icy cold, the wind is hauling around the mast and through the rigs. Then suddenly the wind increases to a full gale; anchor cables break and ships start to drift.

Panic on board. Sailors are running up and down the decks, shouting at each other....words lost in the wind.

A trader bulked with Baltic wheat runs aground on a sandbank. Slowly the waves break the hull. The cargo is lost.

That's how it could have happened.

Preface

In the summer of 1984, a shipwreck was discovered in the Wadden Sea (Netherlands). Shortly before, the ship was exposed from the soil, probably by the changing of the currents in that area. Around the wreck the erosion was strong and severe. In August 1986, the Netherlands Institute for Ship and underwaterArchaeology (NISA) surveyed the wreck, called *Scheurrak SO1* after the site where it has been found, for the first time.[1]

In 1987 this was followed by a more extended survey. It was decided to excavate the wreck. The excavation started in 1989 and ended in 1997.

The wreck itself still lies at the bottom of the Wadden Sea, but plans are being developed to raise it within a few years.

The wreck site is 40 m long and 25 m wide at a depth between 6 and 10 meters (Fig. 48.1). With a keel length of 26 m, the ship itself was probably just over 30 m long. The estimated tonnage is about 130 last. After examination of a few objects, taken from the wreck in 1984 by the discoverer, the ship was dated roughly in the last quarter of the 16th century.

The wood of the ship has been dated by dendrochronology and indicates that the ship was built around 1580 from Westphalia oak wood.[2]

A transitional kind of ship?

Although the wreck is still on the bottom of the sea, we were able to investigate the construction by taking up the stern part and a part of the bow.

It is a flush built vessel constructed according to the "shell-first" method. Here, innovations were fit into the older shipbuilding traditions: to be able to, or maybe even to dare to, built bigger, the ship was constructed with a double layer of shell planking, resulting in an almost self-supporting shell of fourteen cm of thickness. This solution is probably typical for the development in Dutch shipbuilding on the threshold of the Dutch "Golden Age" (Maarleveld, 1994).

It is often difficult to give a type name to a wreck and this case is no exception. Research reveals that the wreck bears many similarities to a "flute", including the round stern of the ship and the tapering boards. According to some historical sources, Pieter Jansz. Liorne designed the Flute in the year 1595 in Hoorn, a place situated on the shores of the Zuyderzee (Van Beylen, 1970). Because of the early dating of the *SO1*-wreck and the fact that the construction hasn't been examined completely, we must be content to call it a "flute-like vessel".

The most important reason to excavate the wreck was the lack of archaeological and historical information about shipbuilding methods in the Netherlands at the end of the 16th century. In the beginning, the research therefore focused on the construction of the ship. Gradually, interest turned to the objects in the wreck as well. Wrecks sink into the soft soil of the Wadden Sea and objects on the bottom of the sea are encapsulated rapidly in the abundant sedimentation of silt and clay. An almost complete inventory among which textiles, ropes and other organic materials has been well preserved for 400 years. About 5000 finds where excavated, conserved and accurately

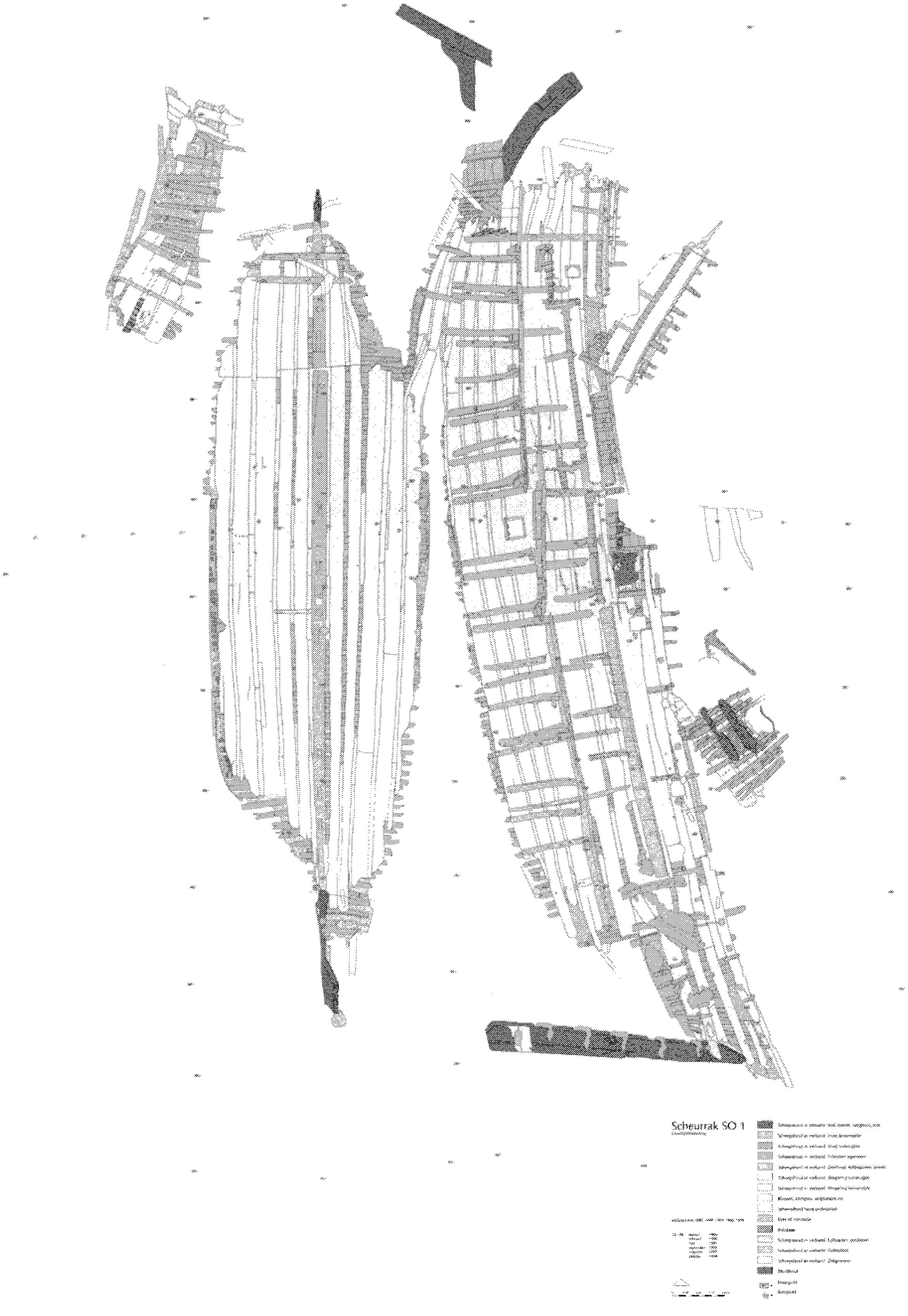

Fig. 48.1. Ground plan of the Scheurrak SO1-*wreck as it was lying on the bottom of the Wadden Sea (drawing: Th.J. Maarleveld, NISA).*

documented. The research on these finds is still in process, but some cautious conclusions can be made.

Bulked wheat

Right from the start of the excavation it was clear that the *Scheurrak SO1*-ship had been loaded with wheat. Large quantities were kept behind the decks of the starboard that had turned over. The hold of the ship had been freed from its wheat a long time ago by the currents. There, *in situ,* roughly cut poles where found, possibly used for carrying a floor of planks. These planks were found all over the wreck. Originally, a layer of bundled straw was put on top of this plank floor followed by the wheat bulked on top (Manders, 1993) (Fig. 48.2). From 16th century sources we know that grain was shipped as a bulk cargo. Despite the risk of mingling different grain cargoes, this proved to be the best method of shipping.

During the excavation woven mats were also found. 16th century accounts state that this kind of mat was placed in between the straw and the grain. Mats were also used to separate different loads of grain. In this way, grains of different qualities from different merchants could be shipped at the same time (Berkenvelder, 1988).[3] The mats found in the *Scheurrak SO1*-wreck may have been used for the same purpose.

The several seeds of weed found in between the wheat samples taken from the wreck, were used to trace the place of origin of the grain load. By combining maps of the 16th century range of distribution of all these weeds, it became clear that Poland was the origin of the wheat cargo.[4] From an historical point of view this is not surprising. The wheat cargo of the *Scheurrak SO1*-wreck probably originated from the Vistula or Weichsel trade: Grain from the interior of Poland was transported on the Vistula river to Dantzig (Gdansk). Most of the grain shipped to Amsterdam came from this area. The grain trade was so important to the Dutch economy of the sixteenth and seventeenth century that it was called the "Mother Trade".[5]

Cargo in casks

Between the first and second deck of the starboard, some 400 staves and 80 head parts of casks were found.[6] The casks were filled with different kinds of goods. Between the parts of some casks, bones of three different kinds of cod were found. These fish were prepared in such a way that it can be stated that the casks contained stockfish.[7] Also casks with shanks of beef (*Bos taurus*), brooms of heather, gunpowder and broad beans (*Vicia faba*) were loaded on board.[8] Fish, beef and beans could be victuals; the brooms were probably part of the cargo. The shape and finish of some staves as well as the presence of bungholes, plugs and faucets, suggest the presence of casks containing liquids.

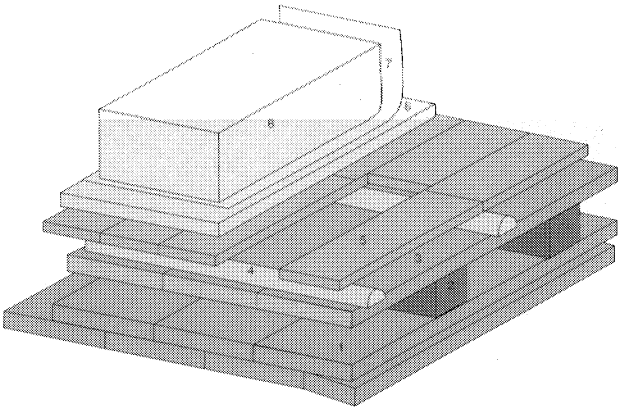

Fig. 48.2. Reconstruction of the way the cargo of wheat was shipped. 1: Double layer of shell planking. 2: Frame timbers. 3: Stringers. 4: Roughly cut poles. 5: Floor of planks. 6: Bundled straw. 7: Woven mat. 8: Cargo of wheat (drawing: M.Manders, M. Kosian NISA/ROB).

The calculated contents of the casks vary between 57 and 182 litres (Manders, 1996). In the near future contents, volume and measurements of the *SO1*-casks will be compared to each other. In this way a comparison can be made with the sizes of casks known from historical records.

Nearly all the recovered casks are made out of oak (*Quercus* sp.). A small number of cask parts made out of beech wood (*Fagus* sp.) have been found in and around the constable room.

All of the *SO1*-casks made out of oak wood were hooped with willow hoops (*Salix* sp.). Hoops are found with and without bark. Hoops with bark are more bendable but are prone to rot because vermin gather under the bark and destroy the willow hoop, especially in wet environments.[9]

During the excavation two bungs were found made out of cork. The habitat of the cork oak (*Quercus suber*) is in the warmer regions of the temperate zones. It does not grow north of southern France and northern Italy.

So far only seven oak cask staves from the wreck have been analysed with dendrochronology, but more extensive dendrochronology research on the *SO1*-casks will soon be undertaken. Two staves could not be dated. On the other hand, the five dated staves yield encouraging results. The wood of two staves is dated after 1554 AD, two around 1596 (+9 –6) and one was dated around 1584 (+9 –6).[10] The oak used for these staves originated from Poland.

Many cask staves and heads bare marks. The marks on these casks can be divided into three groups by outer appearance, namely: scratch, cutting and brand marks (Fig. 48.3).

Scratch marks are usually thin and shallow. They can be made with a knife or another pointed tool. Cutting marks are made with a special kind of tool called a burin and are wider than scratch marks.

Some scratch marks can be related to the cooper, serving as guidelines in the construction of the cask. Other

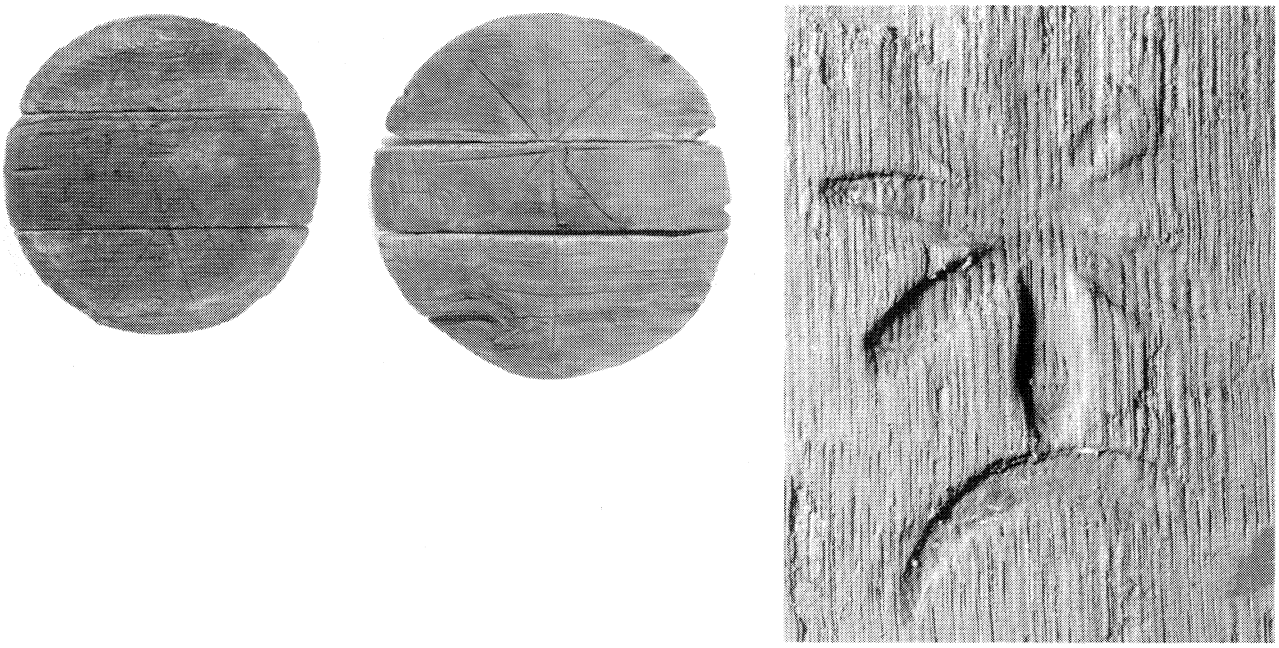

Fig. 48.3. Three different ways of marking a cask. From left to right: scratch marks on a head part, different cutting marks on a head part and a brand mark on a stave (photo: J. Panptit, Leiden University).

scratch marks, as well as the cutting marks, clearly have another function. They may be the ownership marks of a merchant, a skipper or a new owner. Merchants marked their possession and freight. When goods got lost or disagreement arose in loading or unloading, the marks proved ownership. Marks on casks can also indicate a number (for example, amount) or kind of cargo.[11] Here, numbers according to the Flemish as well as (possibly) the German and Arabic tradition were found on several heads and staves.[12]

Wood was also marked after purchase (Kolman, 1993: 1–11) but these marks usually disappeared during the cask-making process. The marks on the cask parts from this wreck were all made during or after fabrication. The roughly made broom cask staves were the only staves that could have had those marks, however none were found.

Although there has been an increase of interest in marks on wood in the last couple of years, studies have been restricted to the collection and registration of the variations. Some cautious interpretations were formed. A logical next step in the research of the origin of the casks from the *Scheurrak SO1*-wreck would be an extended study in the archives of Amsterdam and Gdansk (Dantzig), which would compare the known marks of merchants, skippers and coopers with those on the casks.

One group of marks could be even more effective in tracing the origin of the casks. Every cask made by a cooper of the guild had to be brought in for inspection. After approval, the casks were branded with the mark of the brander, the year or the city's mark. Old or repaired casks, as well as those that came from outside the city, had to be brought in for inspection too.[13] This means, at least theoretically, that each cask had to be inspected and branded every year. Identifying a brand mark from one of the casks of the *Scheurrak SO1*-wreck will possibly mean it can be dated within one year and the city where it has been inspected will be known also.

Personal belongings

During the excavation, many personal belongings were recovered from the wreck, almost exclusively found on the second deck. These include among others; clothing, hats, leather purses and more than hundred used and unused shoes.[14] A few nicely decorated wooden boxes were also found. In those personal tools and other things were kept. Talking about personal belongings: lice and human fleas were found in what it is now clear was a mattress in one of the huts on the second deck.[15] The mattress is made of a mat plaiting of leafs from the small reed-mace (*Typha angustifolia*), filled with straw and probably covered with textile.

A special group of finds are those with texts. In 1989 a trumpet was found in the wreck. Research revealed that it has been used to make signals (Van der Heide, 1994). The trumpet has been engraved with the following words: LISSANDRO MILANESE FECIT GENUA 1589. So the ship must have been wrecked in or after the year 1589. Several wooden objects also bare texts. One example is a knife handle with the name TIMEN MARTE. Probably belonging to a man called Timen Martensz or something like that. The handle was found in one of the wooden boxes that contained a wooden hammer, leather soles and other things related to shoe making. Was the owner a shoemaker? The research in several archives didn't give us much more information yet (Van Tielhof, 1997). Interesting about the box itself is a picture of two ships carved on the inside of the cover, obviously warships equal to the English galleons used during the Spanish Armada (Vos, 1998: 76) (Fig. 48.4).

However, one of the most exciting finds recovered from the wreck, is a 50 cm long wooden linstock (Fig. 48.5). On the handle a little poem is engraved:

DIE AVENT EN DIE MUIERGHEN ZYN NIET EVEN GOET
DEN MOERGHEN MOET SORGHEN DAT DEN AVENT NIET EN DOET
VOUDE DEN AVENT SORGHEN ALS DEN MORGHEN DOET
DAER SONER MENIGH RYEN DIE NU GAEN TEFOET

BYMY CORNELIS CLASOON VAN BLOCK DICK
FFFF ANNO 1590

Blokdijk (Block Dick) is a little village near the city of Hoorn on the shores of the Zuyderzee. In an act of 1590 appears a Cornelis Claesz from Westerblokker.[16] Blokdijk belongs administratively under Westerblokker. This man was a gunner of 23 years old. This fits perfectly with the linstock.

The following navigation instruments were found: a compass, sounding leads, parts of the oldest known Jacob's staff in the world (Fig. 48.6), a closed chart cylinder (unfortunately without a chart) and two pairs of compasses, one with the Amsterdam coat of arms.

Only four Dutch copper coins were found in the wreck. These can be roughly dated between 1574 and 1594.[17] However ten coin weights were recovered as well. Two of them bear the year 1583 and 1584. Some others must have been made after 1586. The weights have been used for French, Portuguese and Dutch coins.[18]

The pieces of red earthenware like cauldrons and a chamber pot (all completely glazed), are of Dutch origin and the stoneware Bartmann jugs originate from the Rhine land (Fig. 48.7). One earthenware pot seems to have another origin, probably the Iberian Peninsula.

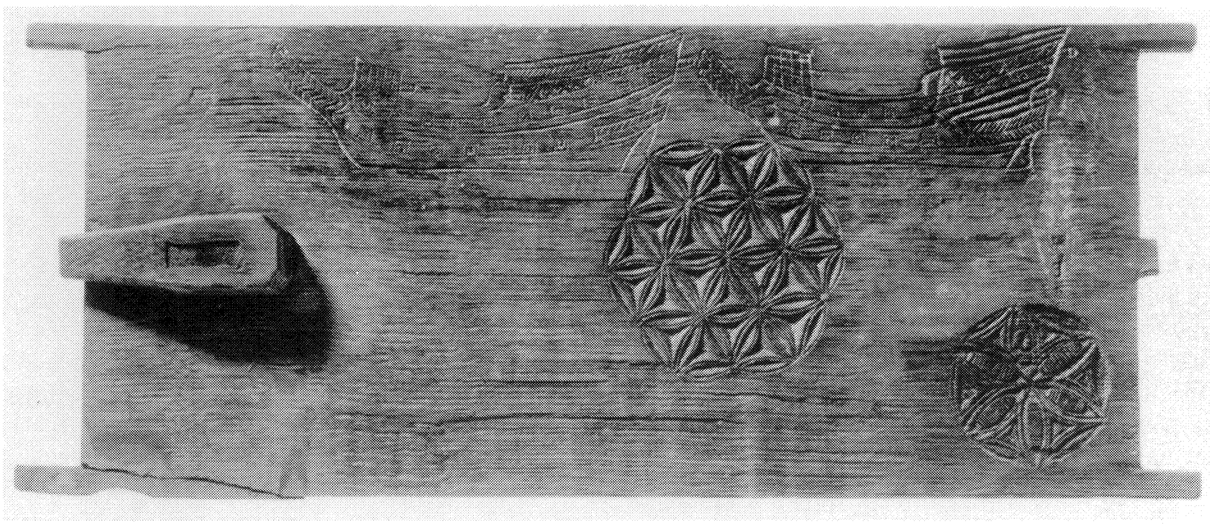

Fig. 48.4. A picture of two ships carved on the inside of the cover of a little wooden box: obviously warships equal to the English galleons used during the Spanish Armada (photo: J. Panptit, Leiden University).

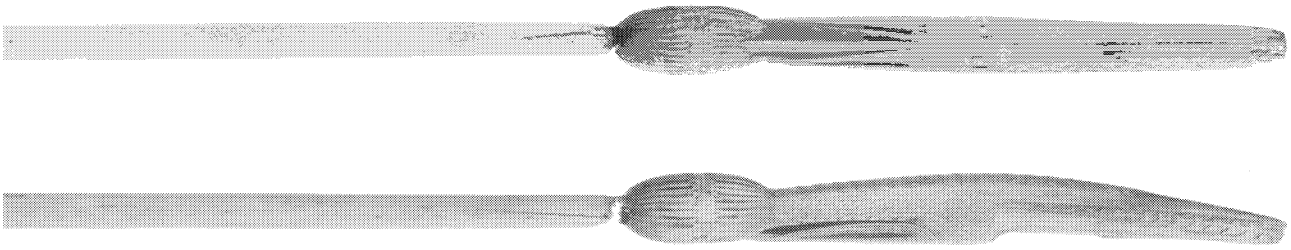

Fig. 48.5. A 50 cm long wooden linstock with a poem engraved on the handle (right) (photo: J. Panptit, Leiden University).

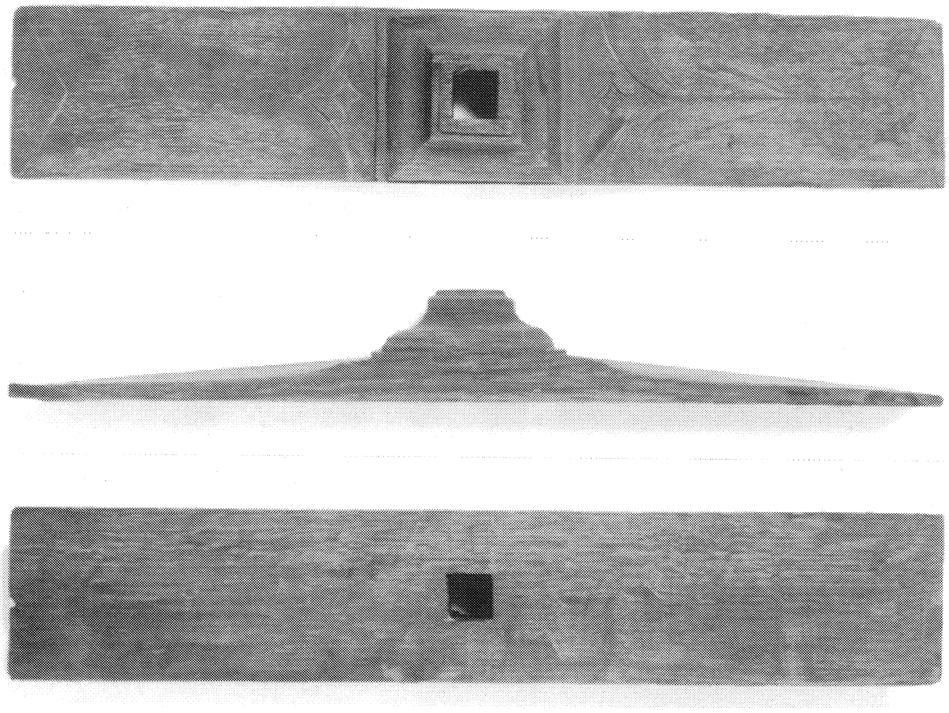

Fig. 48.6. Part of the oldest known Jacob's staff in the world (photo: J. Panptit, Leiden University).

Fig. 48.7. Underwater view of the excavation. In the background: a thick layer of wheat. In the foreground: a Dutch local earthenware chamber pot and three pewter spoons (photo: NISA).

Protected cargo

The *Scheurrak SO1* ship was armed with different kinds of guns and cannons. Exceptional are the parts of five three-wheel gun carriers (Fig. 48.8). In total this ship must have had between 6 to 8 cannons of a small calibre (4, 3 and 2 pounder), several pikes and handguns, including muskets and a number of matchlock carabines with strongly curved so-called petrinals butts. These are the only guns of this type recovered from any wreck known so far. The munitions include several types of spiked shot and canister shot (Puype, in press).

A Dutch ship on its last trip (evaluation and conclusion)

We know the *Scheurrak SO1*-ship was built around 1580 and that it sank in the nineties of the 16th century. It was a Dutch ship with a Dutch crew: the Dutch texts on the finds indicate that, as well as the local earthenware used on board. The Rhineland stoneware was imported in big amounts because of its good quality.

Grain came from Poland. The main cargo of wheat probably came directly from the Vistula area. The oak wood used for the casks, as we have seen, originated in Poland, but were the casks also manufactured there? Oak wood was already scarce in the 16th century Netherlands and large amounts were imported from other places to meet a variety of needs. Wood as a building material for houses and ships came from the Rhineland or Westphalia and was transported downstream on the river Rhine to the Netherlands. Wood was also imported from Poland. Simple rafts loaded with grain, floated down the Vistula to the

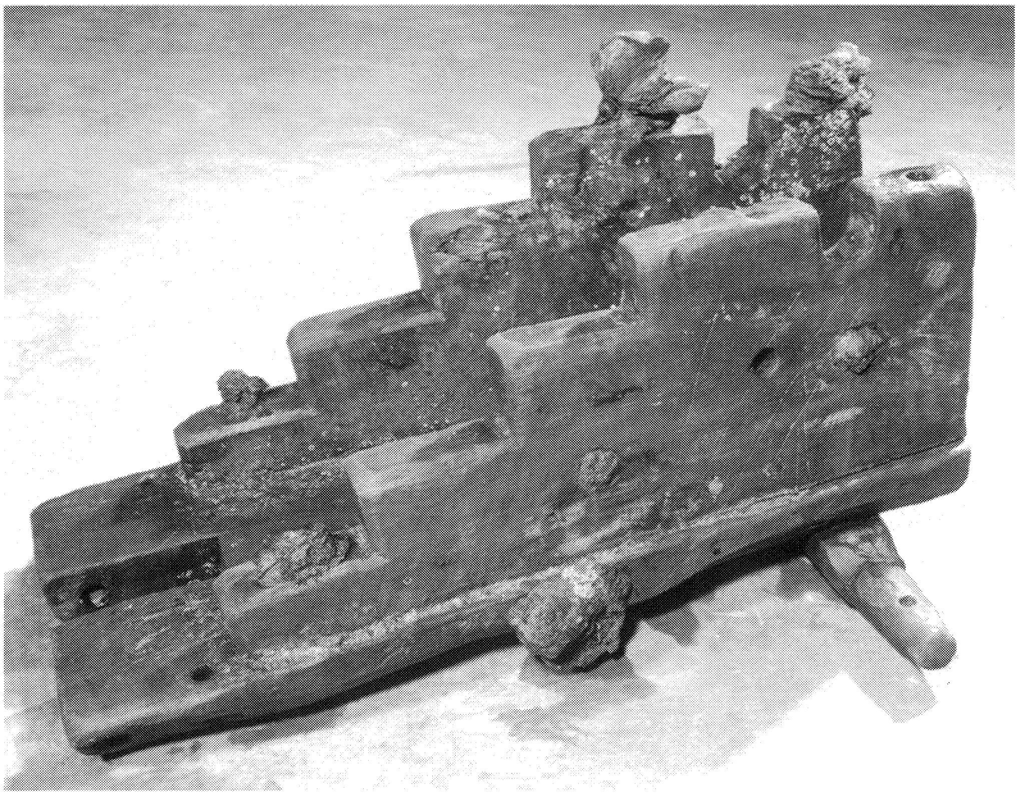

Fig. 48.8. A three-wheel gun carrier (photo: J. Panptit, Leiden University).

port of Dantzig. Not only the grain, but also the wood of the primitive boats was sold on the markets (Smolarek, 1986: 5–23). Records such as the Sound-Toll-Registers show that little planks, called *clapholt*, were exported in huge quantities from Poland into the Netherlands and there is a distinct possibility that the casks, using imported Polish wood, were made elsewhere (Christensen, 1941). So still the question hasn't been solved whether the casks of this wreck were made in Poland or somewhere else. Maybe we will be able to answer that question if we focus our research on the different kinds of marks found on the casks. This archaeological-historical research however still has to be done.

Other finds like a trumpet from Genoa, one little earthenware pot from the Iberian Peninsula, the bungs made out of corks and weights for French and Portuguese coins relate to the Mediterranean area. However the weights are made in the Netherlands and the other objects may be bought or traded at another trip and/or outside the Mediterranean area.

On its last voyage, the ship may have come from Dantzig, with its cargo of wheat (Fig. 48.9). It could have been anchored on the roadstead of Texel to be unloaded for the staple market Amsterdam. Grain arriving on the roadstead was inspected for its quality. If the cargo was in bad shape, it was unloaded and transported to Amsterdam, if the quality was still good, it was an option to send it to another port. Maybe this was the case with this ship. Its final destination could have been the Mediterranean area where it would have sold its wheat for the highest possible price.[19] Here (especially in Italy) there was famine at the end of the eighties and the beginning of the nineties of the 16th century. The armoury can't give us hard evidence to support this idea. We know the route to the Mediterranean was dangerous because of the pirates near Dunkirk and the Straits of Gibraltar and the route to the Baltic was more quiet. The six to eight canons on this ship are average for ships going to Italy, the dangerous route, at the end of the 16th century, but the calibres are very small (Hart, 1978).

What was the reason this ship wrecked in the roadstead of Texel?

During our research we found no evidence of fire or war. The wreck is lying with its starboard site on an old sandbank. Cutting marks on the only piece of the portside we found indicate that after the wreck of the ship, someone tried to get access to the ship's hold. This information indicates that the ship was probably wrecked by a storm. There were only two stormy periods known between 1590 and 1595 in the roadstead of Texel: winter of 1592–93 and 1593–94. Especially Christmas Eve 1593 is notorious. In that night around forty ships, most of them loaded with

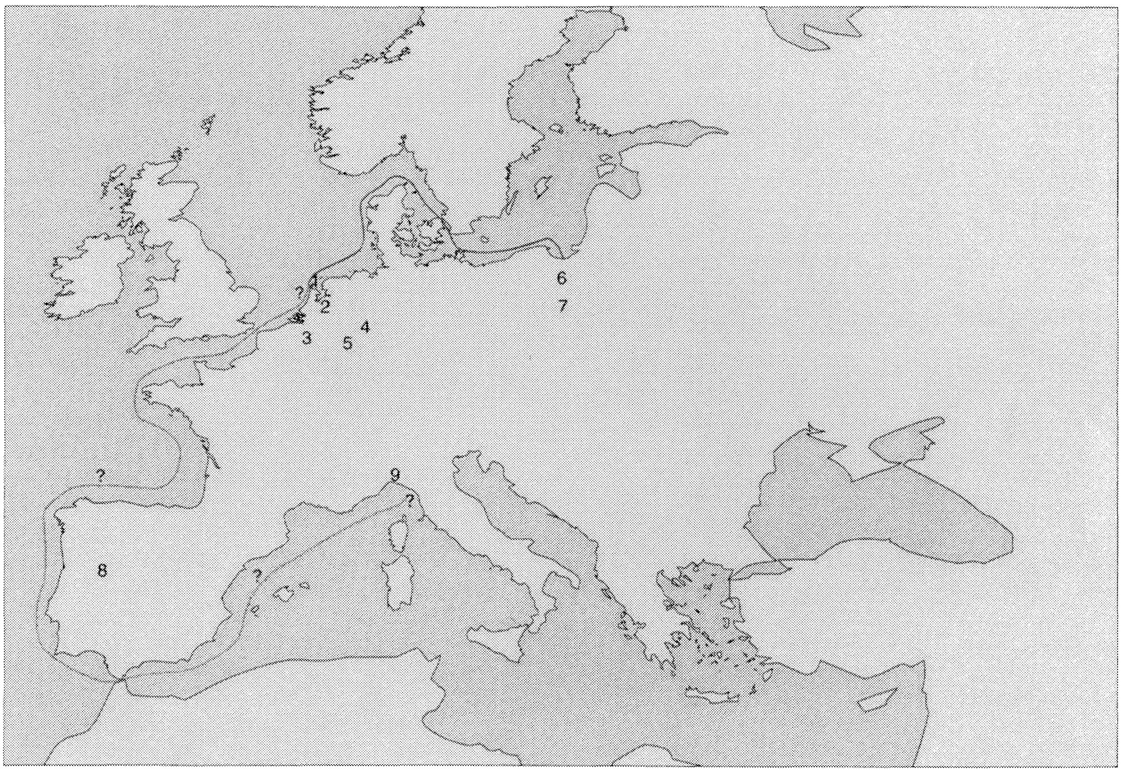

Fig. 48.9. Probably the Scheurrak SO1-*ship came directly from the Baltic area, possibly Dantzig (Gdańsk), shown on this picture by the red line. There are some reasons to believe that the ship had is final destination somewhere in the Mediterranean area (possibly Italy), shown by the dotted line with question marks. 1: The roadstead of Texel. Place of wreckage. 2: The (northern) Netherlands. Origin of the finds with Dutch texts, the coins, the red earthenware, the pairs of compasses and some of the coin weights. 3: The southern Netherlands. Origin of some of the coin weights. 4: Westfalen. Origin of the oak wood used to built the ship. 5: Rhineland. Origin of the stone ware. 6: Poland. Origin of the oak wood used for the construction of the casks. 7: Baltic area (probably Poland). Origin of the wheat cargo. 8: Iberian Peninsula (Portugal?). Possibly the origin of one earthenware pot. 9: Genua, Italy. Origin of the trumpet (drawing: M. Manders, M. Kosian NISA/ROB).*

grain, sunk and hundreds of sailors lost their life (Tielhof, 1997).

We already know a lot about this ship. In the next couple of years, further researches may give us the missing information we need to divine the last route of the ship. Maybe we even get to know the name of the ship.[20]

What we do know is that this ship is a perfect example of a trader involved in the Dutch grain trade to the Baltic – the most important trade for the Dutch economy for centuries – the corner stone to build the Dutch Golden Age on.

Notes

[1] SO means Scheurrak Omdraai, an area situated in the Wadden Sea.

[2] Dating by RING, Amersfoort

[3] Archive Daniel van der Meulen nr. 153.

[4] Manders (1993).

[5] On the twelfth of February 1999 a debate has been taken place about this issue in the Maritime Museum of Amsterdam. One of the conclusions was that the "Mother Trade" or "Moedernegotie" possibly even formed the base of the Dutch Golden Age.

[6] Around four hundred staves and eighty head parts are found (Manders, 1996).

[7] The three different kinds of cod are *Gadus morrhua*, *Brosme brosme* and *Molva molva/Molva dypterygia*. The last two kinds are probably caught in the northern part of the North Sea, maybe even more north of that (see Brinkhuizen, 1994: 197–205).

[8] Broad beans of the type that is still consumed by us, *Vicia faba* variety *major* has rarely been found during archaeological excavations. These beans are amongst the oldest examples ever found in an archaeological context. By oral communication W. Kuijper (University of Leiden). See Zeiler, 1994 for his publication about the shanks of beef.

[9] The willow hoops were connected according to the *"vissebekjesmethode"* or *"fishmouth method"* (Manders, 1996: 44–46).

[10] The cutting dates of the last three staves are precise due to the presence of sapwood. This means the last ring of heartwood is present as well. Sapwood was frequently present on the staves of the roughly cut broom casks. The calculation for the estimated amount of missing sapwood rings is based on an average of 15 (plus 9, minus 6) for Polish oak. When there's no sapwood present, it's unknown how many heartwood rings are missing. By consequence, the cutting date can only be estimated in a rough manner, as we can see for the first two dated staves. Dating and information by RING, Amersfoort.

[11] Ross (1980: 162) suggests a few casks of the *San Juan wreck* (Red Bay, Canada) bare Roman numbers. The reason for this is not clear to him.

[12] On one head part the Arabic numbers 2 and 41 are cut. This way of numbering (the same way we do it nowadays) has come to use for marking in the 16th century. The Flemish numbering has long been the standard to number wood in the Netherlands. The German tradition has been rarely used (Manders, 1996).

[13] *"De selve sullen mede gehouden zijn/ alle jaren tusschen de 1 Januarij ende den 1 May/ haer lieder oude vaten te doen hermeten ende herbranden/........De vaten die sy bevinden sullen haer goede ende oprechte maet te houden/ sullen sy hebben te branden met het wapen van de stadt/ ende 't jaer vande brandinghe op de buyck van de tonne/ ende op een andere duyge van daer de meesters merck staet/ op correctie van de heeren van den gerechte."* (Geest, 1659: appendix).

[14] Some of the unused shoes are marked with a cross on the sole. These shoes probably belong to the cargo.

[15] Analyses by J. Schelvis from Scarab, Widum in the Netherlands.

[16] Archive Westfriese Gemeenten (Hoorn), Notarial Archive 2036, p. 148–149.

[17] Single (province) and double (Philips II) copper "Duiten".

[18] The coin weight makers are Hans Foncq and Lennaert van de Gheere (III). The weights were used for: 1 Vlies, 1/2 & 1Rozenobel, 2 Cruzado, 1/2 & 1 Statendaalder, 1 Bourgondische Rijksdaalder, 1 Ecu and 1/2 Leeuwendaalder.

[19] In Dutch called a *"doorgaande vaart"*.

[20] An indication for the name could be a carved wheel on a plank belonging to a panel on the stern.

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49. Whipstaff and Helmsman
An Account of the Steering-gear of the Vasa

Olof Pipping

Introduction

Vasa capsized during her maiden voyage 1628. The wreck was salvaged in 1961 with the hull proper undamaged and it has furthermore been possible to replace ornamental and other details that had dropped from the ship's upper parts over the years.

The whipstaff steering system of *Vasa* was found *in situ*. This kind of system was used in the 17th century and replaced by the steering-wheel in the early 18th century. The remnants of a man in his late twenties were also found in the steeridge, the room where the helmsman works. Investigation of the bones (During *et al.*, 1994) showed he had been subject to trauma earlier in life causing damages to the cartilage in the elbow joints, injuries that presumably might originate from work as helmsman in big ships.

As yet it has not been possible to find any contemporary sources describing the whipstaff-gear and 19th and 20th century accounts are mainly the result of guesswork based on defective information available before the salvage of *Vasa*. It was decided to investigate the system in order to study its mechanical properties as well as test how this kind of steering-gear might influence a person.

Study

Geometrical measurements (Stolt, 1980: figs. 1–7) from *Vasa*, studies of the parts of the system combined with investigations and calculations provided data on the mechanical properties and ergonomics of the system. Calculations of hydrodynamic forces was made by Mr. P. Trägårdh, SSPA Maritime Consulting, Gothenburg. Prof. M. Lesser and his students at the Division of Mechanics at the Royal Institute of Technology in Stockholm in cooperation with carpenters of the Vasamuseum created a full-scale whipstaff simulator connected to a computer simulating the characteristics of factors affecting a helmsman in a ship. Prof. Lesser also made a virtual simulation of forces acting on a skeleton in order to see how external impulses affects a person.

Archaeological evidence

In *Vasa* the system includes the rudder with bottom pintle and gudgeon preserved, the helm, the whipstaff, the sweep, the rowle, the rowle bearings and wooden pieces covering the rowle. A spare helm and a spare whipstaff were also found (Fig. 49.1).

The rudder was fitted to the sternpost with seven pintles and gudgeons. The cross-section of the rudder is wedge-shaped with the thick edge aft.

The helm enters the gunroom through the opening in the transom and ends under the steeridge. The tiller rides on a sweep mounted across the gunroom, halfway up. On the underside of the tiller there is a cut-out for a roller or a small slide. There is a large hole in the lower end of the whipstaff fitting around the fore end of the tiller, this having a hole for a locking-pin (Figs. 49.2, 49.3).

The rowle through which the whipstaff passes is fitted in the deck in the steeridge. The journals of the rowle fit in bearings, the upper parts of which are covered by two blocks of wood carved as a grotesque face with the whipstaff sticking out of its mouth.

Reconstruction

The parts of the *Vasa* steering-gear have been put back in the ship after conservation and even though they cannot be moved anymore the function can be reconstructed making a three-dimensional model supplemented with virtual simulation (Lesser *et al.*, 1998). The whipstaff is used to manipulate the tiller at a distance, which is a prerequisite for seeing a compass. When the helmsman moves the whipstaff from side to side the fore end of the tiller moves horizontally in the opposite direction thereby changing the angle of the rudder relative to the ship's centre-line. For greater rudder angles the helmsman has to push the whipstaff sideways through the rowle and at maximum rudder angle only the top of the whipstaff can be seen above the rowle.

When the hull came to rest in the mud the end of the tiller came to be put hard against the ship's port side, which can be proved with the whipstaff. It is eroded but less so where it has been protected by the rowle, which shows that the parts of the steering-gear have been in this position for a long time.

A notch cut in a deck carling above the tiller shows that the intention was to use the entire width of the gunroom for the travel of the forward end of the tiller. The notch was made to prevent the whipstaff from getting stuck at hard a-port helm and cut already before *Vasa's* maiden voyage. There is a notch in the opposite carling on the starboard side as well, ruling out the possibility of an erosion instead of a cut on the port side.

The top of the whipstaff was broken, but the spare whipstaff is undamaged and this shows that the whipstaff was broken at a hole made a few inches from the top.

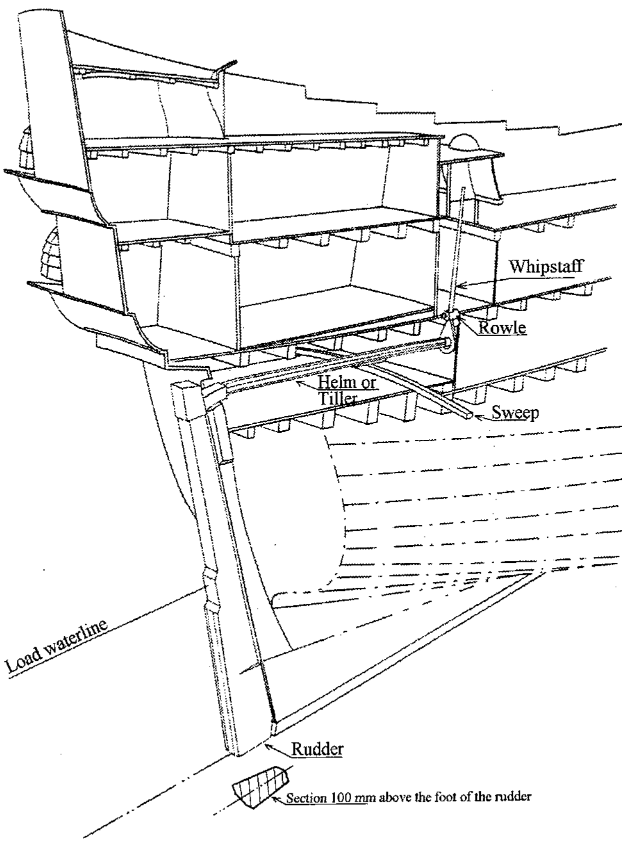

Fig. 49.1. Longitudinal section (after Pipping, 1994; 1998).

Discussion

The parts of the steering-gear are on the whole in agreement with descriptions written later in the 17th century.

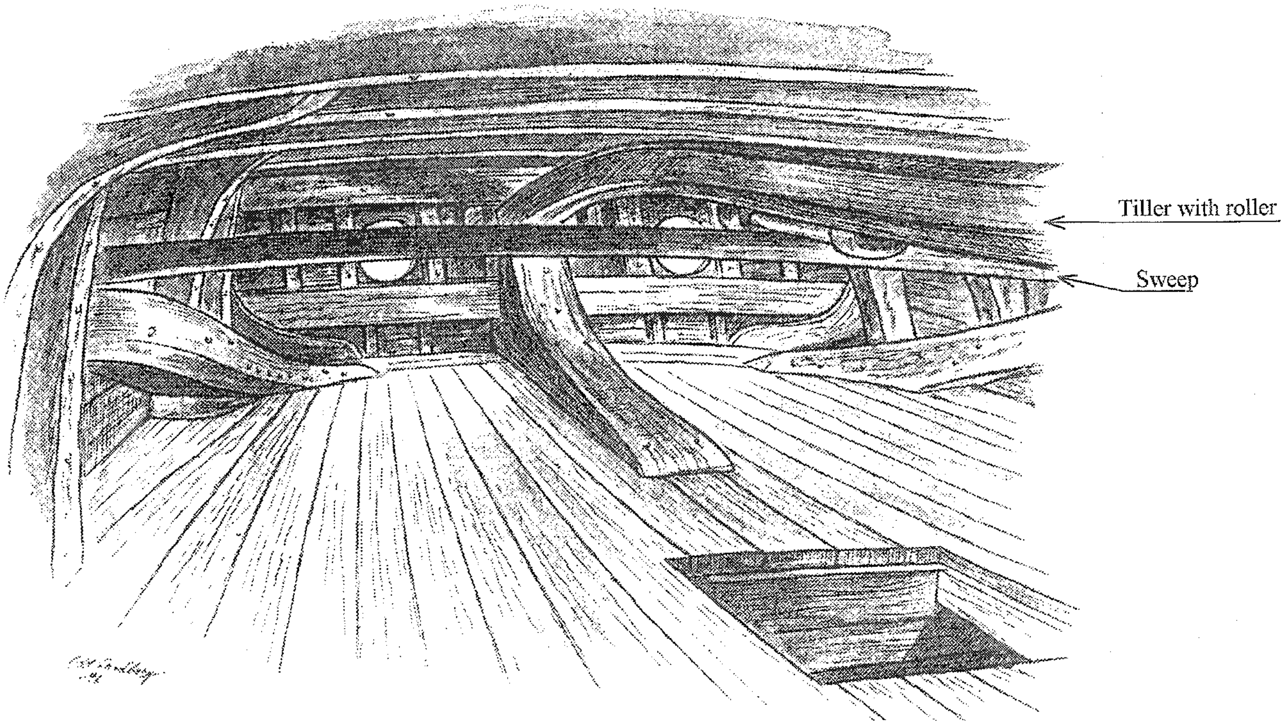

Fig. 49.2. The gun room. View towards the stern (after Sandberg, 1996).

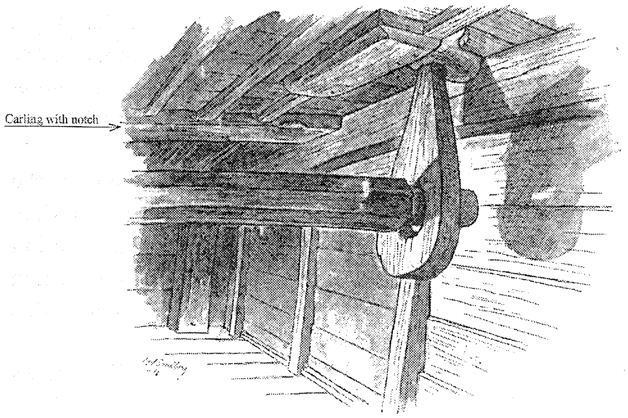

Fig. 49.3. The gun room. Fore end of tiller with whipstaff and rowle (after Sandberg, 1996).

The differences are that all details of the steering-gear in *Vasa* are entirely made of wood, except the rudder irons, whereas late 17th century sources tell us about iron fittings like a *sleeve* at the lower end of the whipstaff and a *crank* or a *tang* on the fore end of the tiller (Rålamb, 1691; Boudriot, 1978). Later sources also states that the sweep is fastened to the deck above with the tiller moving close under the deck which would be the reason for a tang on the tiller to obtain the necessary distance between the end of the tiller and the rowle (Smith, 1653; 1691).

The lack of contemporary sources makes it impossible to say whether the position of the sweep in *Vasa* was characteristic of the period or not. The vertical position of the sweep may in this case depend upon the necessary vertical distance between the fore end of the tiller and the rowle. It may also have been considered important for members of the crew to help the helmsman by pushing directly on the tiller, which would require the tiller at a certain height above the gunroom deck. The fore and aft placing of the sweep seems to be a compromise between its function and the need for enough space for the two guns in the fore end of the gunroom and the two guns pointing aft.

It is important to note that the sweep in *Vasa* can be taken down to facilitate work with the guns and shifting of the tiller. The gunroom is also the living quarters for the petty officers and perhaps they were allowed to take down the sweep when the ship was riding at anchor.

A contemporary author (Mainwaring, 1623) writes that it is impossible to use the whipstaff in big ships. It can be shown, however, that *Vasa* must be ranged among the big ships (Glete, 1995) at the time of the shipwreck. It should also be noted here that there are no other remains of steering facilities as for example tackles, except the hole at the top of the whipstaff. The *Royal Sovereign* – launched in 1637 – was steered with tackles (G.P.B.N., 1947) whereas *Kronan* – launched in 1668 (pers. comm. Jahrehorn, 1999) – and *Le Royal Louis* – launched in 1692 (Vaughan, 1913) – both had whipstaffs. All these ships were much bigger than *Vasa*, *Le Royal Louis* of 4220 tonnes displacement (Halldin *et al.*, 1963), *Royal Sovereign* of 2450 tonnes (Halldin *et al.*, 1963: 149–153), *Kronan* of 2150 tonnes (Halldin *et al.*, 1963) as compared with *Vasa's* 1200 tonnes displacement (Hofmann, 1966: fig. 183).

Whether the size and form of the rudder follows set rules is difficult to know. It is safe to say that a rudder as narrow as possible was desirable (Mainwaring, 1623) as the demands on the strength of the helmsman grow very fast if the rudder is made wider. The width of the rudder falls within the rules of proportions, which are known from later times (Witsen, 1671).

It seems as if the shipwright who built *Vasa* was aware of the importance of the dimensions of the cross-section of the rudder. The rudder is wedge-shaped with the thick edge aft and the fore edge follows the same thickness as the sternpost, which together with the garboard and lower strakes are thicker at the heel.

The helmsman's duty is to hold or change the course under various conditions according to the commanding officer's orders (Mainwaring, 1623), not least in battle, and to steer the course by means of compass, sails and relative motions of sea, land or sky (Mainwaring, 1623). To fulfil his tasks he must have possibilities to adjust the position of the tiller, orientate and keep in touch with the commanding officer. Aboard *Vasa* the helmsman was placed in a steeridge with room for a binnacle with a lighted compass as described later (Smith, 1691). The arrangement of the steeridge with two doors leading to the upper deck indicates a sound and direct communication between helmsman and commanding officer, whose duty-station seems to have been on the upper deck immediately forward of the steeridge and there is no need for an intermediary as in the *Royal Sovereign* of 1637 (G.P.B.N., 1947).

In *Vasa* the helmsman's view of the surroundings is restricted to a part of the rigging where he can see a few of the sails, but he cannot see land or horizon. These restrictions are intentional as can be seen from the sets of specifications written when ordering new ships for the Swedish Navy in 1649 (Flemingh, 1649), which clearly state that the steeridge is intended to protect the helmsman from musket shots. Seeing sails, part of the sky and the compass gives sufficient information for the helmsman to do his job (Mainwaring, 1623).

Other than that there is no information about how the work of steering with a whipstaff was organized. Some indirect information is known but it is far from exhaustive. However, steering with whipstaff seems to have been a one man's job (Mainwaring, 1623; Flemingh, 1649; von Rosenfeldt, 1689; von Rosenfeldt, *circa* 1690; Smith, 1691), possibly with a helmsman's mate or mates assisting at the whipstaff or the tiller (Mainwaring, 1623; Vaughan, 1914).

The work of Prof. Lesser and his students has indicated the need to get a better grip on the whipstaff to be able to draw it up again after the helm has been put hard over. A possible arrangement could have been a grommet or a lanyard fastened to the hole in the whipstaff functioning as a handle to draw it up or down through the rowle (Franklin, 1989). Such an arrangement would also allow someone to assist the helmsman (Defoe, 1719).

In case of loss of the whipstaff, damage to the steeridge or conditions demanding more force than the helmsman can generate there must be other ways of steering. Of course, one way is to let several men handle the tiller directly and steer her like a boat (Vaughan, 1914) and a contemporary source mention steering tackles (Mainwaring, 1623). We have not found any traces of such in *Vasa* but tackles fastened by the gun ports could have been hooked onto the tiller in an emergency. The same source mentions a rope functioning as brake on the tiller and such a rope could also be fastened to the fittings of the guns.

Vasa was built for the operations of the Swedish Navy, which mostly took place in the Baltic Sea at a time when the ships were fitted out for campaigns in the spring and laid up in late autumn. The campaigns also included transports to Finland and the Baltic countries and to the operations in Poland and Germany, including blockades of the coasts of the latter countries. Therefore, the demands on the manoeuvrability of ships was high as this service may be seen as navigation in narrow coastal waters with quickly changing weather. Considering tactical ability there is an instruction by Admiral Henrich Fleming dated in September 1628 in the Danzig roads. He instructed every Captain and Lieutenant in (this) fleet (in the Danzig roads) to see to it that their ships could make quick manoeuvres, explicitly including tacking (Fleming, 1628). Considering the manoeuvrability when sailing one must also remember the use of the sails to increase the effect of the rudder (Mainwaring, 1623).

In *Vasa* the rudder angle is determined by the dimensions of the hull and the length of the tiller, which in this case allows 22 degrees a side, and given the Admiral's requirements above we can take it that this was considered an angle good enough to produce the desired effect (Fig. 49.4).

It is possible that a certain angle was decided upon determined by the necessary length (leverage) of the tiller, and that a greater virtual angle was sought by forming the rudder since the section of the *Vasa* rudder would increase the effective rudder angle with some 1.5 degrees (Trägårdh, 2000). Angles greater than 30 degrees were in any case hardly ever used with pintle-and-gudgeon rudders in sailing ships as they would brake rather than steer (Chapman, 1768).

The lines of the run and the lower parts of the hull forward of the rudder must also be considered as they influence the efficiency of the rudder (Mott, 1997). These aspects concerning *Vasa* have not yet been investigated as the flow around the afterbody have only been treated with the block coefficient of the hull as argument.

Conclusions

A comprehensive study of the steering-gear is possible because the dimensions of both ship and steering-gear are known and information of her draught is noted in the minutes from the inquiry after the shipwreck. These data together with modern computations and simulation methods make it possible to investigate the flow around the hull and thereby the forces acting upon the steering-gear and the helmsman as well as the characteristics of the system.

Computations of the hydrodynamic forces acting on the steering-gear indicate that the force the helmsman has to apply is reasonable and the analysis of the ergonomics (Lesser *et al.*, 1998) indicates that normally the forces acting on the whipstaff would not lead to such damages that were found on the preserved bones. This does not exclude that the helmsman might be subject to extreme forces if he looses control.

Furthermore, the results show that there must have been a system of relief as vibrations in the gear would cause physical damages to a helmsman in the long run and with a steering-gear like that of *Vasa* only half an hour at the helm would be allowed today.

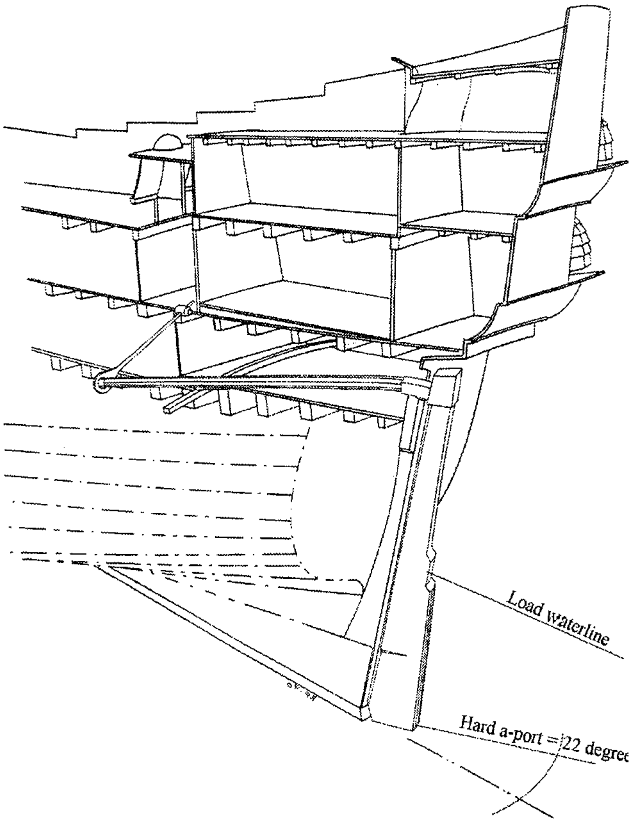

Fig. 49.4. Hard a-port. The hole at the top of the whipstaff is now immediately above the rowle. The archaeologists found the steering-gear in this position in 1961 (after Pipping, 1994; 1998).

Nevertheless, the results indicate that the steering-gear of *Vasa* fulfils the technical ideas of her time, which remained in force more or less unchanged for another hundred years.

Acknowledgements

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Notes

[1] For a comprehensive list of references and notes see Pipping, 2000.

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50. Maritime Ethnography: The Reality of Analogy

Lucy Blue

This paper has been inspired by five years field work conducted by Prof. Sean McGrail, Dr Eric Kentley, Mr Colin Palmer and the author in India, as part of the 'The Boats of South Asia' project, funded by the Society for South Asian Studies. Its title is perhaps a little ambiguous so I will start by defining maritime ethnography.

Maritime ethnography 'is the study of contemporary maritime cultures and their materials, through first hand observation'. By undertaking maritime ethnographic research we are essentially compiling a record of the *reality*, as we perceive it, of present day maritime cultures and their materials, in this case boats.

Maritime ethnography has a number of applications:

- one application is as a research tool in its own right, that is, as a record of a culture and of their vessels. In fact, in the Indian sub-continent, such studies offer a relatively rare ethnographic resource with a unique range of boat types still used by a variety of different cultures. However, it is becoming increasingly evident that boat-building traditions are rapidly changing, and that wooden vessels are being replaced by metal and glass reinforced plastic, and being fitted with engines;
- another application of maritime ethnography introduces the concept of *analogy*, when we begin to try and apply ethnographic data to an interpretation of archaeological material (Wylie, 1985).

As McGrail expressed: 'Ethnographic studies can make the archaeologist aware of a range of solutions to general problems... Using such ethnographic analogies... the archaeologist can... propose hypothetical reconstruction's of incomplete objects or structures, suggest the possible function of enigmatic structural elements and describe in some detail how an object or structure was made' (McGrail, 1984: 149–150). Analogy can be applied to both broad relationships as well as to specific archaeological contexts. It provides 'clues' (Childe, 1956: 49) or suggests 'ways of thinking' (Binford, 1972: 49) as to how to visualise past cultures, serving as a base line or a launch pad for retrospective enquiry. Thus, to an extent, analogous applications of ethnography to archaeology allow us to breach temporal and spatial gaps by using information derived from one context (the present) to help explain data found in another context (the past) (Johnson, 1999: 48).

This paper will attempt to outline some of the difficulties inherent in both acquiring and interpreting maritime ethnographic data and also of applying it analogically to archaeological contexts.

Maritime ethnography is a relatively new tool at the disposal of maritime archaeologists (most work having previously been undertaken in Scandinavia (Hasslöf *et al.*, 1972) and North America (Gould, 1983). As a new tool we need to be careful to characterise our data, determine the variables we are considering, and not base interpretations on assumptions of function alone. In order to demonstrate the complexity of this issue, this paper will focus on one aspect that I believe is fundamental to maritime enquires, and one that has relevance to both the analysis of ethnographic and archaeological data. That is *how or why a boat is the shape it is?* Which also has implications on why it is built and used in a particular place?

In this respect McKee, particularly in his book *Working Boats of Britain* (1983; 1997) addressed the criteria that influenced the choice of boat shape. Factors such as the environment, function, propulsion and available building materials are discussed. He goes on to suggests that 'the shape of boats must depend a great deal upon the personality of the men who build and use them' (McKee, 1997: 44). By outlining so many variables McKee was approaching the question objectively. He was in effect suggesting that the picture was more complex: that there were and are many other factors that influence the shape of a boat beyond simply 'functionalist' concerns. But did McKee address all the criteria?

If we look at interpretations of other materials in the archaeological record such as pottery or house types that have received more attention than boats, then we find that historically archaeologists interpreted data largely from an implicit perspective of function. When analysing a pot questions were asked such as how was it made and what was its use, and how does its shape and decoration compare to other vessels? More recently, however, materials have been addressed from a broader, more explicit perspective of their social context and symbolic nature, as well as their functional and typological applications (Trigger, 1989).

If we now address archaeological interpretations of boat finds we see similar patterns emerging. In the same way that western scientific thinking with a focus on function influenced interpretations of terrestrial archaeological data, comparable implicit assumptions have been made with respect to maritime material. These assumptions, I would suggest, are centred on notions of function, of the environment and of available building materials. Statements such as 'To appreciate a boat one must be aware of the factors that give rise to her building, the timber available, the general environment, the building traditions of the society which produced her and, above all, the purpose for which she was built' (Greenhill, 1995: 21). There is no denying that the shape of a boat is influenced by these criteria. But do these criteria alone paint the full picture? In order for a comprehensive analysis to be undertaken we need to interrogate the ethnographic data, outline and examine a wider range of variables that influence boat shape, and then consider all variables in the same light. By addressing the boat in its broadest context, communicating with the boat builders and users – asking them questions about their boats and their view of the world; by no longer approaching the object in isolation; *then a far more complex, explicit picture will emerge.*

Thus, by attempting to identify the variables that determine the shape of a boat in an ethnographic context, we can then perhaps begin to provide a more comprehensive set of criteria with which to address the interpretation of archaeological remains.

In January 2000, a small-scale pilot survey was undertaken in Tamil Nadu, southern India by the author and Mr Colin Palmer. The aim of this survey was to develop the argument outlined above by addressing the broad ethnographic (and perhaps archaeological) context of the vessels in this region. We were essentially asking questions about the incentives behind the shape, building and use of particular vessels in particular places. The methodology adopted attempted to classify boat shapes, boat types and boat places using a number of different attributes, in order to establish correlation's which may explain why certain craft are used from specific landing places, whilst others are not.

Having identified particular craft, their type, structural characteristics and means of propulsion, a number of variables were identified that potentially influence boat shape. The following list of variables was designed simply as an initial guide from which to develop the enquiry:

- function – criteria that influence the purpose or use for which a boat was built, the operations, such as fishing and particular fishing practices, trade or transportation, which the craft is intended to undertake;
- technology – the level of technology available to construct/ power the vessel;
- material resources – available building materials, including tools;
- environment – the operating environment of the vessel. This includes consideration of topography (land and sea), maritime conditions (weather, sea state, tidal range), formal/ informal landing places, geographic change etc.;
- economy – economic climate within which the boats are constructed, primarily available resources with respect to labour, funds, time. Other concerns are economic status, co-operative support, available markets, and government intervention in the form of subsidies, fisheries policy etc.;
- socio-religious context – mostly subjective influences to do with religion, cultural context, superstition, ritual, and symbolism. Essentially the local 'traditions', ideas and ideology within which the craft are constructed.

These variables were products of numerous influences, some objective needs of the boat builder and user relating to structure and use, while others were subjective influences of cultural context or constraints of environment, technology or economy (Chapman, 1768; Adams, 2001). Some criteria no doubt are more important than others in dictating boat shape; all have different roles to play.

Each of these variables were assessed through various means of analysis, primarily observation and interview. Using a methodology adapted from rural development studies (Participative Rural Appraisal) (Chambers, 1983; Townsley, 1993) that focuses on general themes of enquiry rather than structured questions, boat builders and boat users were interviewed with the aim of encouraging discussion. This informal approach allowed the interviewees to tell us what they actually believed rather than what they thought we wanted to here, or what prescribed questionnaires dictated.

However, problems were incurred. Interviews were conducted through an interpreter and, partially due to the subjective nature of the questions, and the complexity of the issues, some information was lost in translation. On occasion we suspect that interpreters told us what they thought we wanted to hear, or what they believed, rather than what the boat builders or boat users were actually saying. Others problems of perception were also encountered. Differences in boat shape were identified that we perceived as significant to the use of the boat. However, the boat users placed far less onus on the concept of shape, they tended to associate a vessel directly with its operation, or refer to its name, which varied for the same boat in different regions (Weski, in press), rather than attributing any importance to its shape.

However, although difficulties in structuring and interpreting the results were encountered, we began to address the fundamental question. We began to identify specific criteria that influenced the shape of vessels, narrowing down, defining and weighting the variables in order of importance. The survey highlighted a number of considerations. That the criteria for the selection of craft are indeed quite complex, and that contrasting and often conflicting factors can apply, and, that more numerous variables determine boat shape, not just available building material and environment. The following examples should exemplify these points.

As part of the 1997 and 1999 seasons of the 'Boats of South Asia' project the construction, design and use of a plank built boat called the *vattai* were documented (Blue, Kentley, McGrail 1998; McGrail, in press). The *vattai* is a flat bottomed, frame-first, heavily constructed vessel that was observed operating in the shallow, calm, muddy waters of the northern shores of Palk Bay (Fig. 50.1). It is an open fishing boat predominantly propelled by sails, with balance boards and leeboards. *Vattai* fishermen were documented undertaking gill net fishing and trawling. In summary, *vattai* observed in 1997 and 1999 were operating in the relatively calm, muddy, shallow waters of northern Palk Bay.

In contrast, during the pilot survey conducted in 2000 along a short length of coastline bordering Palk Bay and the Gulf Mannar (Palk Straits) (Fig. 50.1), *vattai* were observed being used in a completely different environment. In the Pamban (Danaskodi) region off the southern shores of the Palk Straits, *vattai*, here known as *karavallai*, were observed operating off a surf beach. They were also being used for a different type of fishing, beach seining, and had an alternative means of propulsion (exclusively by rowing).

In addition, not only were similar types of vessel observed operating in a different coastal environment but extremely different craft were noted operating alongside one another in the same environment. Along the same beach we observed log rafts from Cape Comorin in the south (engaged in seasonally migrational fishing operations), beach seining *vattai* (here known as *karavallai*), and motorised *vallam*.

Log rafts and boats of flexible hull construction such as the sewn planked, frame-less *masula*, have traditionally been used along this coast as they are suitable for operating in the surf zone. *Masula* are currently employed between Orissa (in the north) and the Kaveri Delta (in the south) and historically were used for lighterage but more recently beach seining operations (Kentley, 1985; Deloche, 1994: 179–183). Yet here at Danaskodi heavily framed, rigidly constructed vessels (*karavallai*) were observed beach seining through the surf. Similarly, in West Bengal and Orissa reverse-clinker *patia*, usually involved in coastal fishing under sail, were observed undertaking comparable seining operations in a similar surf environment (Kentley, McGrail, Blue, 1999). These examples clearly illustrate that rigidly constructed hulls as well as flexibly built hulls and log rafts are practicable for seining through the surf.

One could conclude that the use of the same vessel in two such different environments and operating regimes, and so many different vessels operating in a similar environment, could not be more diverse. But as stated our observations were largely made along a short length of coastline and during seasonal operations. Were these atypical examples? Had the *vattai* owners simply relocated for the season in the hope of increasing their catch? Initial observations suggested that boats of *vattai* type largely restrict their operations to calmer, shallow waters, such as the northern shores of Palk Bay where the majority of *vattai* were observed. However, recent observations supplemented by future research, may revise preliminary thoughts and perhaps, the archaeological analogy to be drawn.

Thus, although we are beginning to indicate that the relationship between the shape of a vessel and the environment in which it operates is not always linear, the picture is very complex and further consultation and field work is required before the variables outlined above can be refined. Future research would therefore focus on a limited number of boat types and environments in order to reduce the complexity of the sample and provide a control by which to identify the relative importance of the varying criteria. This could be achieved in a number of ways:

- by assessing the fishing communities perception of boat shape versus use and thus to seek to identify the complex range of factors that have resulted in, for example the *vattai*, being used in two such different ways and contrasting environments. As noted earlier this is not always straightforward as subjective notions of shape are not always communicated clearly through discussions with boat users – photographs and other aids are often required;
- another approach could be to address a similar 'type' of vessel over a broader area, noting the variations in shape and attempting to establish the criteria that influence these variables. The log raft of southern India (known locally as catamaran) would be an interesting craft to address. Catamaran rafts are believed to have operated along the coasts of India for many centuries (Hornell, 1920: 169–170; Thivakaran, Rajamanickam, 1992) and thus we assume a more optimal shaped craft has evolved, with possible retrospective analogous comparisons to historical and potential archaeological material. The catamaran currently operates over a broad geographical area from southern Kerela in the south to Orissa in the northeast, and essentially off steeply shelving beaches across the surf zone. However, the construction of these craft, yet to be classified, varies from region to region, yet the environment and fishing operations appear to be similar. By recording varieties of this distinctive vessel type and attempting to understand why the shape of the raft varies from region to region,

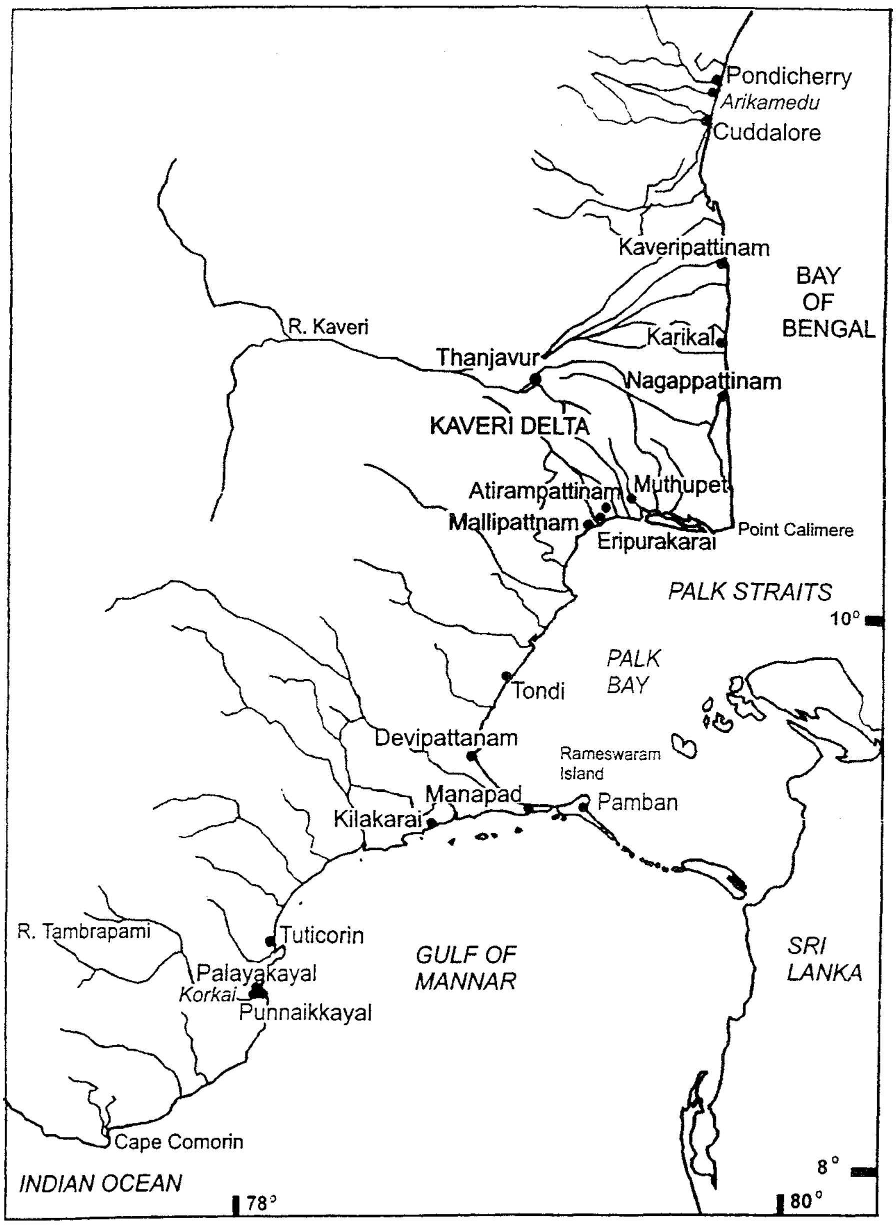
Pondicherry
Arikamedu
Cuddalore
Kaveripattinam
BAY OF BENGAL
R. Kaveri
Thanjavur
Karikal
Nagappattinam
KAVERI DELTA
Atirampattinam
Muthupet
Mallipattnam
Eripurakarai
Point Calimere
PALK STRAITS
10°
PALK BAY
Tondi
Devipattanam
Rameswaram Island
Manapad
Pamban
Kilakarai
R. Tambrapami
Tuticorin
Palayakayal
Korkai
Punnaikkayal
GULF OF MANNAR
SRI LANKA
Cape Comorin
INDIAN OCEAN
78°
8°
80°

Fig. 50.1. Map of central coastal Tamil Nadu, southern India, locating the places referred to in the text.

> we hope to further refine the criteria for the selection of particular craft in a particular context and identify the boundaries between 'similarity' and 'difference' principally with respect to the determination of boat shape.

At this stage we have few answers, in fact more questions and variables to consider. But, through observation and discussions with the fishing communities, initial enquiries have confirmed that the criteria for the selection of craft are extremely complex. That additional determinants such as the socio-economic context of the community, the fish resource, and religious and culture considerations, amongst others, require consideration. Future research would aim to comprehensively investigate and identify positive corelations between the variable factors that influence the construction, shape and use of craft.

The 'Boats of South Asia' project has drawn attention to the urgency of ethnographic boat recording in a region which still offers a relatively rare ethnographic resource with a unique range of boat types still used by a variety of cultures along a diverse coastline. At present direct archaeological evidence for boats in India is extremely limited (Blue, Kentley, McGrail, 1997) and likewise so are any analogous comparisons that may be drawn between ethnographic and archaeological data. However, an enquiry of this nature is timely, as it provides an unequaled opportunity to study and document at first hand a finite resource whilst at the same time addressing broader issues of ethnographic content. Only when ethnographic data of this nature is compiled can analogies possibly be drawn with archaeological material yet to be discovered in the region. Ultimately, this will aid the study of vessels in India and world-wide, and perhaps shed light on the prehistoric uses of water transport, providing a powerful tool with which to address the reality of applying ethnographic analogy to interpretations of archaeological material.

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51. A Comparison Between the Earliest Testimonies of Venetian Construction Techniques and those of the Present Day

Gilberto Penzo

Introduction

Venice offers the naval researcher an unrivalled variety of vessels; hundreds of types of boats and ships have been passed down over the centuries and many of these are still used by this population of enthusiastic carpenters.

In our opinion this abundance of research-material has not been adequately studied. The history of Venetian naval architecture – like Italian history in general – has yet to be written. In Italy, little attention is paid to naval culture, and the few researchers who have dedicated themselves to the subject – none of them professionals – work independently of each other. This means that there is no precise way of comparing the results of their studies – a comparison that would either stimulate further research or would rapidly settle differing opinions and establish fixed points of reference. Above all, this research is, in our opinion, compromised by the fact that it is detached from the world of boatbuilding and sailing.

To avoid making the same errors, we decided to conduct our research using a lengthier approach, but one which we feel has more scientific validity. We began by collecting and classifying all the material relating to the subject and, for the moment, resisting the (strong) temptation to apply theories of our own to the evolution of Venetian boats and ships or to their traditional construction methods.

Our task was to separate the opinions of historians, ourselves included, from the historical sources. The *Archive of Sources for Italian Naval History* which we are creating will, we hope, be a common and verifiable base from which we and other researchers will be able to draw information.

Naturally such a vast and unexplored field of research posed an urgent problem of priorities: the work of the historian is often first and foremost a work of preserving memories. Therefore we set aside the written documents, which could wait, in order to dedicate our energies to the ethnographic world which is disappearing (Fig. 51.1).

The surviving boatbuilders who use, or used, the traditional methods are all in their eighties; they have no apprentices and the small number of their sons who continue the family's traditional work admit that they do not know how to construct the boats built by their fathers. When the old boatbuilders have died, the loss of accumulated experience will be similar to the burning down of an archive.

We began by collecting and classifying historical evidence directly from the boatbuilders, fishermen, sailors, sail-makers, rope-makers and anyone involved in marine activity. Whenever possible the evidence was also recorded on audiotape to preserve the local pronunciation. Particular attention was paid to the collection of *sesti* and *sagome* (templates) from Venetian boatyards. When it was not possible to acquire them physically full-size drawings were made (Fig. 51.2).

To learn the traditional construction techniques without preconceptions, we had to set aside our scholastic background and enter the boatyards not as experts, but as apprentices. From the accounts of the protagonists and the teachings of the *maestri d'ascia* (master boatbuilders), the history of Venetian boatbuilding comes over as a rich and complex world, apparently conservative, but full of suddenly rejected techniques and innovative ways of accelerating the construction process; a world in which ancient boats which have remained unchanged coexist alongside continual variations or innovations. No ship or boatbuilder (or client) can resist the temptation to try to improve the performance of a vessel while it is under construction. Transformations came about as a function of changes of route, traffic, armaments, fishing techniques, the sea bed, and – why not? – changing aesthetic taste.

The other important source is the *corpus* of manuscripts of naval techniques which the shipbuilders of the Venetian *Arsenale* have left us: notebooks in which information relating to the construction of a large number of ships is transcribed in detail. These precious texts are difficult to interpret because they are written in a mixture of ancient Venetian dialect and shipbuilders' slang, and because they

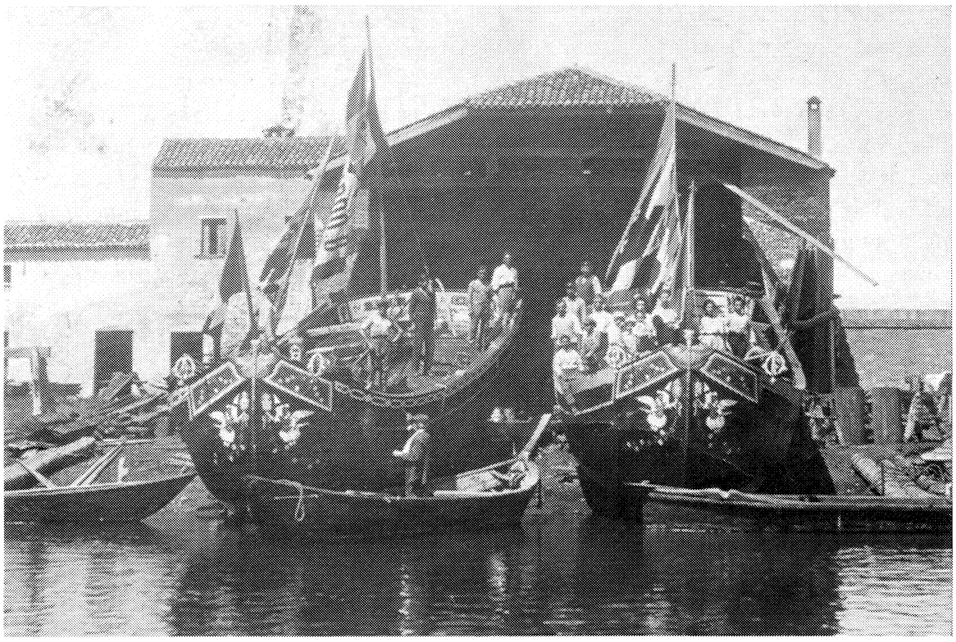

Fig. 51.1 An image of Penzo family's boatyard in Chioggia: the launching of two seagoing bragossi.

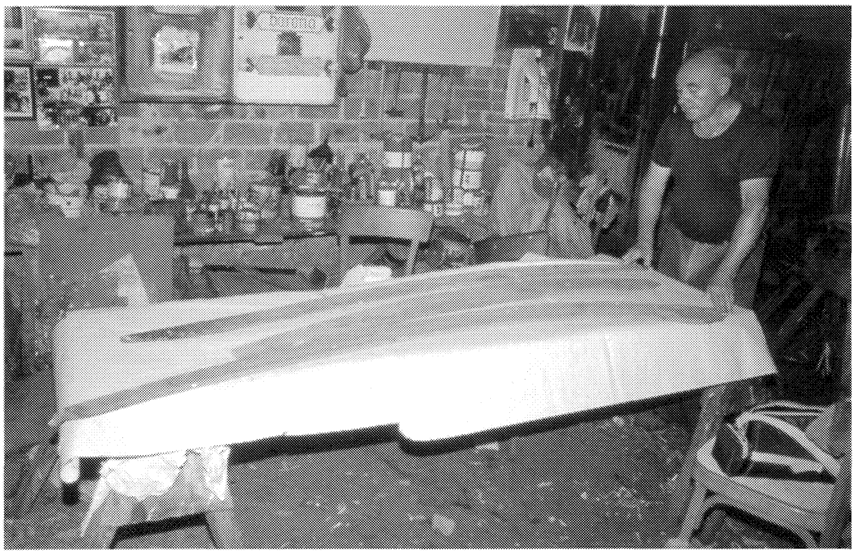

Fig. 51.2 The boatbuilder Schiavon during the survey of the templates used in his boatyard.

take for granted the reader's familiarity with the construction techniques they describe.

As well as these texts we have discovered a large number of notebooks written by private builders at the beginning of the twentieth century that, surprisingly, give the same amount of information and use the same language as their fellow boatbuilders used six centuries before. A facsimile edition of the first volume of this series, the *Libro de rason* by Prè Theodoro de Nicolò, kept in the Marciana National Library of Venice, is due to be published shortly.

The information in these manuscripts gave us a better understanding of some construction methods referred to by the builders and, conversely, the builders' explanations helped to clarify a number of obscure stages described in the manuscripts.

Other important sources of information are the technical drawings, models, and the boats themselves. All the drawings of ancient ships and boats which we were able to consult have already been published, but it should be remembered that 'naval drawing' as the term is understood today, is a relatively recent invention. All the ships and boats, whatever their size, were always made (and are still made) with reference to *sesti* and *sagome*. The drawings which do exist can be classified in three categories: surveys taken after construction; drawings used for bureaucratic purposes; and drawings to show the client how the final product would appear. Rather than using drawings to define the design of a vessel, models (such as those of the *Arsenale*) were used so that the *proto* (foreman) could check the progess of the forms. These models are being catalogued in the same way as the drawings.

We will conclude our examination of the sources with the surveys of the boats. As well as recording the form of the boats, these surveys recorded the details, the construction methods and the marks left by tools. Naturally, whenever possible, we try to save these last examples of the historic boat for conservation by museums or private collectors. It should be pointed out here that the Italian government encourages their eradication since any fisherman who wants to build a new boat must destroy the equivalent tonnage of old boats in the presence of a state official (Fig. 51.3).

All data collected from each of these various sources were then interpolated so as to highlight the differences or agreements between them, and the words and phrases of the boatbuilders' terminology were compiled into a dictionary that will be published soon. It should be remembered that the same considerations which are valid for the Italian language can be applied to this 'marine terminology': it is not a single language but a combination of a number of dialects: Venetian, Ligurian, Neapolitan, Tuscan, languages which were then forced together in the official marine language devised after the unification of Italy, a language in which many of the terms were invented and never used in practice.

The next steps were the drawing of the construction plans and the construction of models: firstly scientific models, secondly carpenter's models, and finally seaworthy replicas. Models and boats were then subjected to a thorough examination by the *squerarioli* (Venetian boatbuilders) who needed no persuading to point out the slightest defect. Any inconsistencies were then checked again with our interpretations of the sources (Fig. 51.4).

I apologise if I have spoken about this scientific approach to historical study for too long, but while the methodology is commonly used in the more informed centres abroad, in Italy it is being adopted with difficulty, because other less rigorous qualities are preferred such as imagination and improvisation.

Venetian Construction Techniques

From our integrated comparison between historical sources and the methods of contemporary craftsmen it emerges that before the end of the Second World War construction techniques did not undergo significant changes from earlier centuries, whether in small boats or large ships.

The techniques of design and construction, the means of transport and wood-cutting, the tools, the nomenclature and graphic symbols, the methods of bending the lengths of wood, the techniques of rowing, navigating and fishing, the painting and maintenance – all these have remained similar if not identical.

Many boatbuilders still use the ancient units of measurement, at least six centuries old, based on the *piede* (foot), its multiples *passéto* (small pace) and *passo* (pace) and on

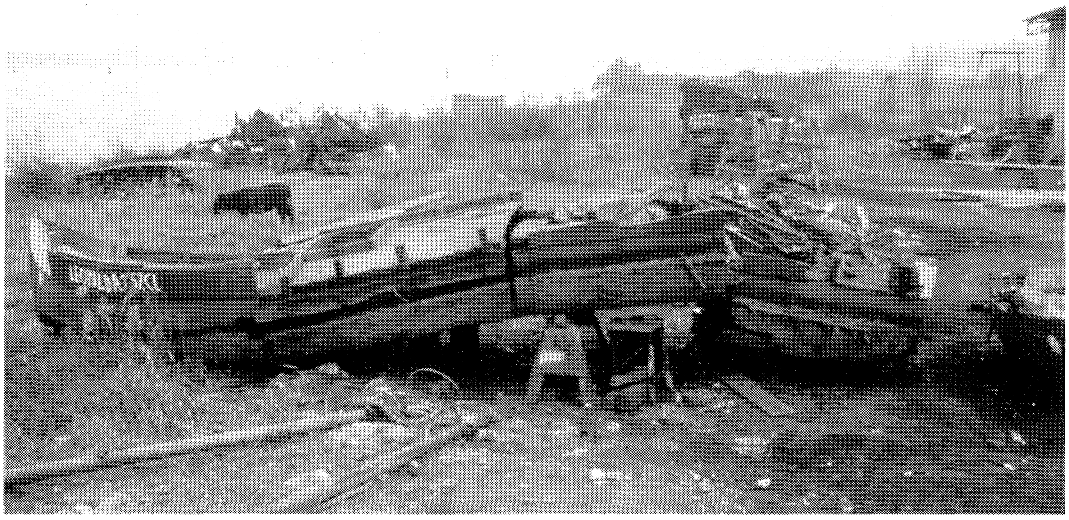

Fig. 51.3 The hull of a bragosso *that has just been destroyed for tonnage regulations.*

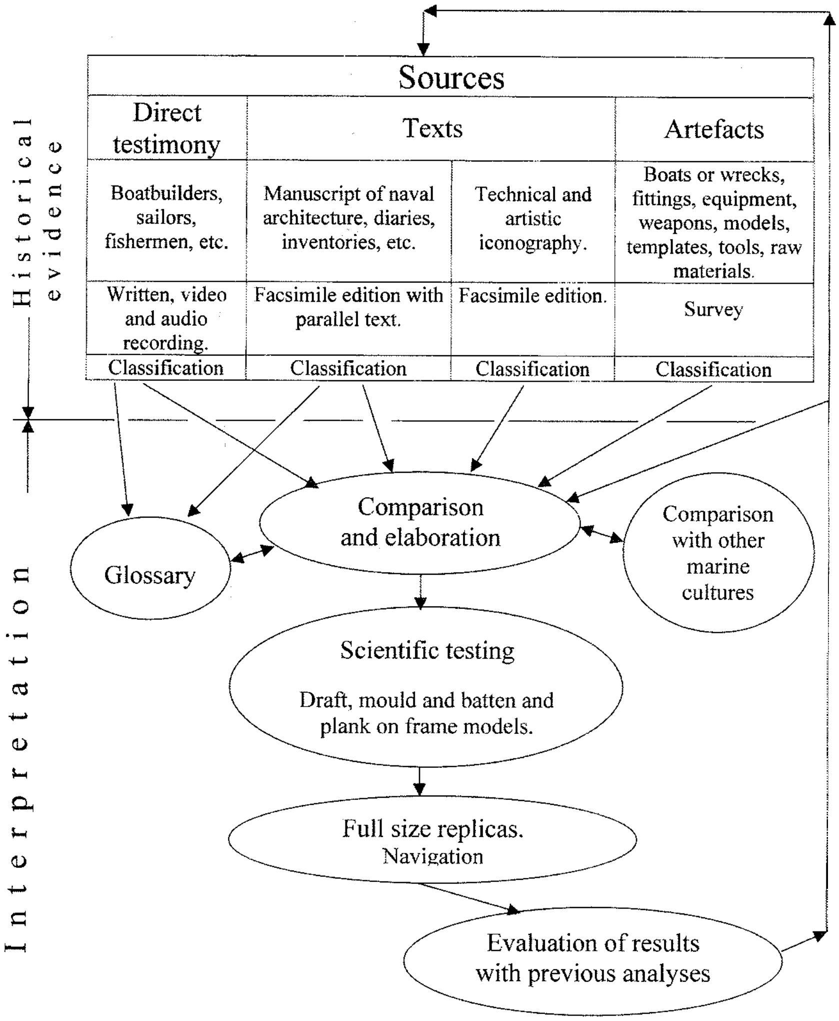
Sources
Direct testimony
Texts
Artefacts
Boatbuilders, sailors, fishermen, etc.
Manuscript of naval architecture, diaries, inventories, etc.
Technical and artistic iconography.
Boats or wrecks, fittings, equipment, weapons, models, templates, tools, raw materials.
Written, video and audio recording.
Facsimile edition with parallel text.
Facsimile edition.
Survey
Classification
Classification
Classification
Classification
Historical evidence
Interpretation
Comparison and elaboration
Glossary
Comparison with other marine cultures
Scientific testing
Draft, mould and batten and plank on frame models.
Full size replicas. Navigation
Evaluation of results with previous analyses

Fig. 51.4 Criteria of working methods used by the Centro Ricerche Navali.

a vast number of divisions such as the *palmo* (span, palm), the *quarta*, the *ónsa*, the *deo* (finger) the *linea* (line) and the *canna* (rod). They have kept these units for certain formats of timber or for reference measurements even after conforming to the metric system; converting these measurements to metres and centimetres would involve long strings of decimal places which would be difficult to memorise.

The boatbuilders continue to use their special graphic symbols to indicate the principal parts of the boat: midships, the stern, the bow, and the conspicuous points known as *posélesi* (Fig. 51.5). They use, or remember the use of the various methods of dividing a segment progressively employing either *moreli* (two short sticks) and a triangle, or the semicircle method.

Other signs are still used when surveying the unbent length of the strakes by means of a *cantinela* (batten) and a stick soaked in red powder contained in the small solid wood box called the *cassela d'ambuoro* (Figs. 51.6, 51.7).

Traditional naval construction uses carvel build on a supporting skeleton, based essentially on the direct design of the hull modelled in thin wooden templates called *sagome* which are used to trace the outline of the wood being worked. Some of these *sagome* called *sesti* allow, by means of a system of movements guided by special signs, the tracing of a series of shapes which gradually differ in relation to the others, as in the case of the sections (Fig. 51.8).

The boatbuilder always begins from the *cantièr*, the slightly upward-curving plank that will support the entire boat whether it has a keel or is flat-bottomed. At either end of the *cantièr* the two sticks modelled with the respective templates are positioned at the correct angle. Then once the *cantièr* has been subdivided into the required number of sections, the midship section and the two end sections are fixed.

The points positioned at the end of the sticks on the three principal sections, or *cai de sesto,* form a fixed path which the *sercio* or *magèr de bóca* must follow to avoid depressions or irregularities. This way a very small amount

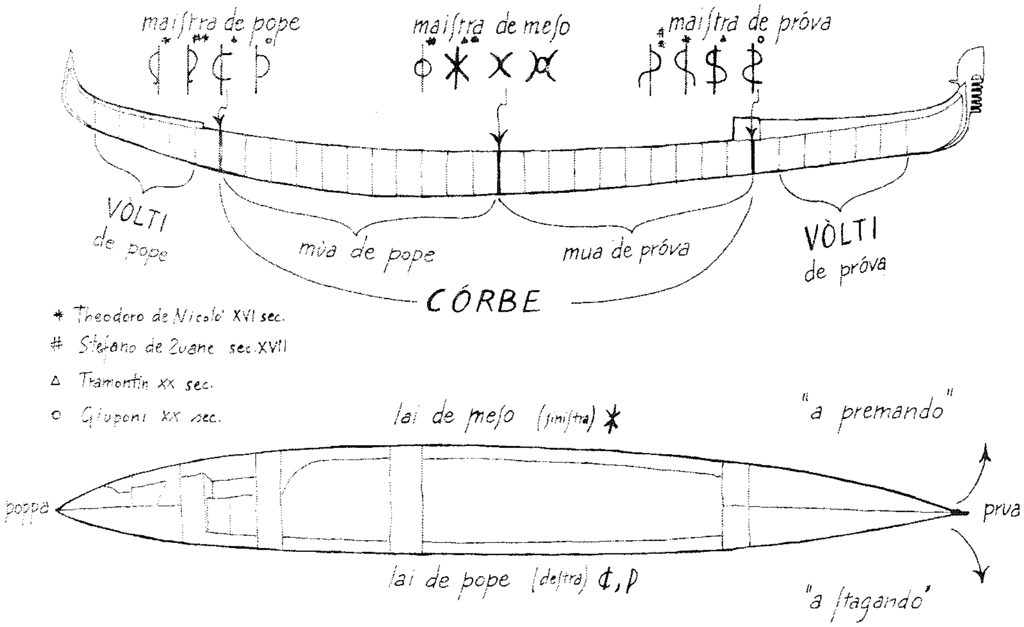
maiſtra de pope
maiſtra de meſo
maiſtra de próva
VÒLTI de pope
mùa de pope
mua de próva
VÒLTI de próva
CÓRBE
* Theodoro de Nicolò XVI sec.
# Stefano de Zuane sec. XVII
△ Tramontin XX sec.
○ Giuponi XX sec.
lai de meſo (ſiniſtra)
"a premando"
poppa
prva
lai de pope (deſtra)
"a ſtagando"

Fig. 51.5 Graphic symbols used by the boatbuilders to indicate the stern, bow and midship, the posélesi *and the nomenclature of the sections.*

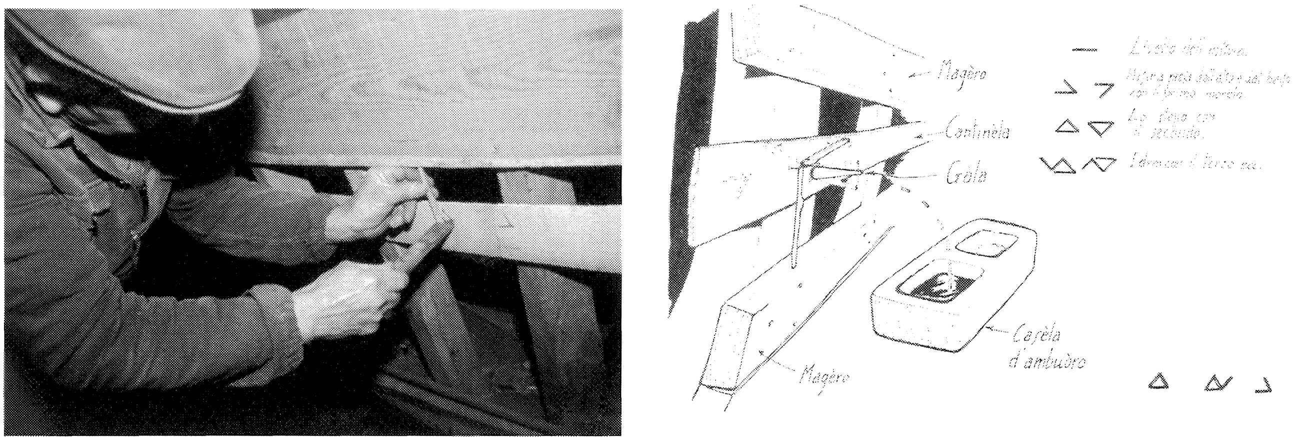
Magèro
Cantinèla
Gòla
Caſèla d'ambuòro
Magèro

Fig. 51.6, 51.7 Method used to survey the shape of a strake, and the relative set of symbols.

of information needs to be remembered to record the form of each boat. It is interesting to note that in the case of the *sesti* (so precise that they are used to trace all the sections), the *squerarioli* continue to fix the three master sections and the first band of planking before inserting the other sections (Fig. 51.9).

Traditional Venetian construction, in common with that of every other country, is based to a large extent on working *A ocio* (by eye/by rule of thumb) which is often erroneously taken to mean 'at random' or 'lacking precision', when it actually means 'guided by my eye', a guide which can be very precise when precision is called for, as demonstrated by the lines traced on the *sesti* separated by steps of less than a millimetre. The traditional boatbuilder does not apply the same rigid tolerances to the entire vessel; he knows when to be precise and when to compromise. We should bear in mind that a boat is not an abstract entity, but a real artefact made with wood, and having all the imperfections intrinsic to the material. If a block of wood had an imperfection, it was not thrown away; rather the profile of the piece was retouched or the potentially fragile part was positioned at a point not subjected to stresses. The whole thing resembled – if you will forgive the daring comparison – a sculpture by Michelangelo where smoothed surfaces alternated with areas that were deliberately left without finish, where the

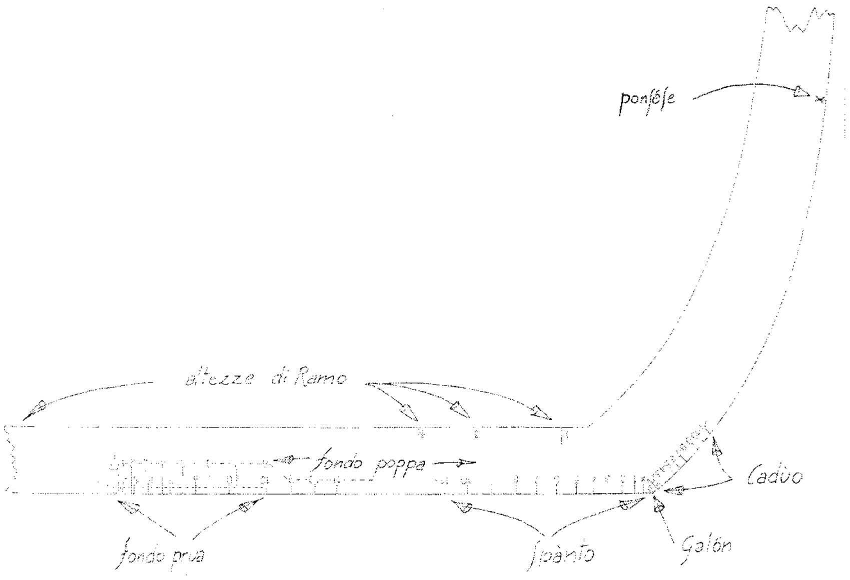
ponfèſe
altezze di Ramo
fondo poppa
Cadùo
fondo prua
ſpànto
Galòn

Fig. 51.8 Templates for a gondola, and traditional nomenclature.

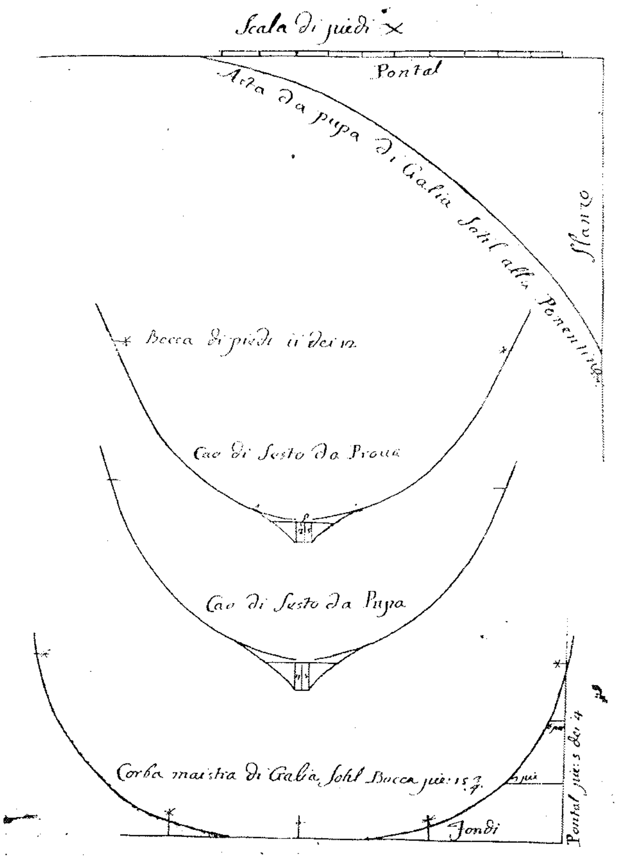
Scala di piedi X
Pontal
Asta da Pupa di Galia Sotil alla Ponentina
Slanzo
Bocca di piedi ii dei 12
Cao di Sesto da Proua
Cao di Sesto da Pupa
Corba maistra di Galia Sotil Bocca piei 15 3/4
Pontal piei 5 dei 4
Fondi

Fig. 51.9 Drawings of the three principal sections corba maistra *and* cai di sesto *are also included in the page of the manuscript by Stefano de Zuane dedicated to* Galia sotil alla ponentina.

tool-marks can be seen. This result was virile and expressive: an effect that reconstructions of historic boats do not often have, as they are made entirely by machine – with clean edges which give the idea of something dry and artificial.

It should be stressed that the boatbuilders were intransigent not only as to the form of the boat, but also over details which we would define as aesthetic or of secondary importance; no boatbuilder would have neglected to finish a *mancolo* (mooring bitt) or a *zogia* (garland) according to the rigid traditional criteria. Thus the same boat could have parts which were brutally rough cut in areas normally out of view, but also elaborate decorations on its edges, on the wale or on the bulwark

A Comparison Between Two Manuscripts

To bring out the similarities between the ancient and contemporary boatbuilders, we will compare two manuscripts: one from the mid-sixteenth century (Fig. 51.10) and one from 1920 (Fig. 51.11); two worlds chronologically and spatially distant from each other. One belongs to the *Arsenale*, the other to a small private boatyard of one of the islands of the lagoon. The pages we have selected refer to a large warship, the other to a small fishing boat. As can be seen, a small page of manuscript is sufficient to contain all the information considered important, the rest – omitted – was part of the individual know-how passed from father to son.

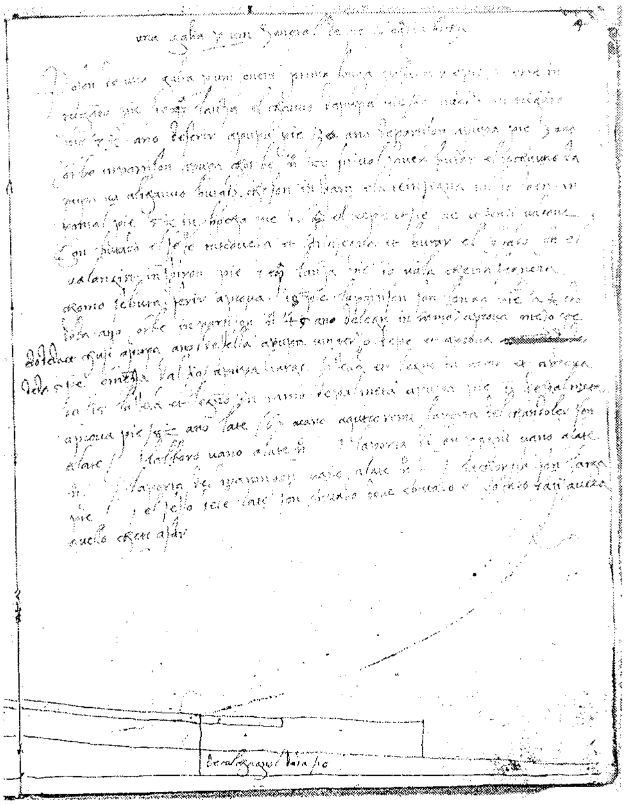

Fig. 51.10 Libro de rason *by Pre' Todaro de Nicolò, instructions for building a* Galia per un zeneral *(Galley for a general).*

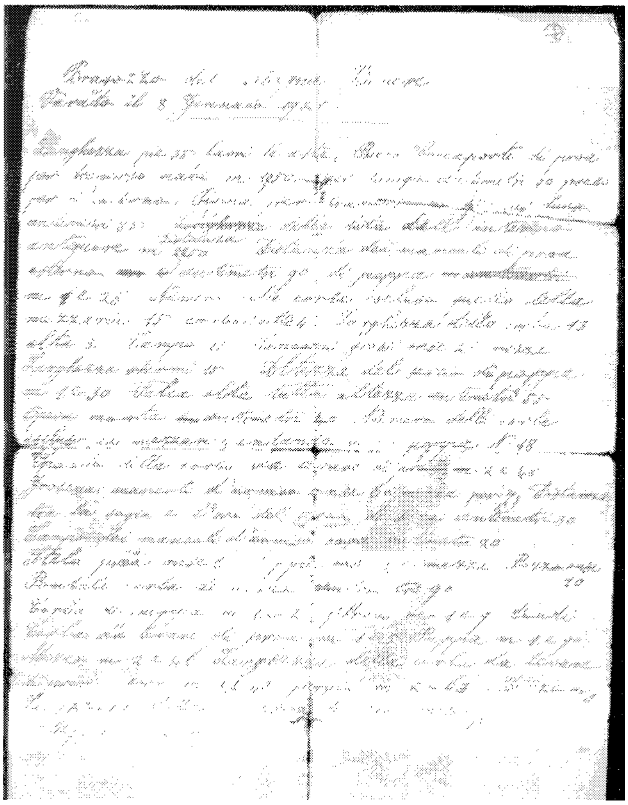

Fig. 51.11 Manuscript by Aristide Bertotto, notes for building a bragosso.

The most important instructions are always the same: memorise with the smallest amount of data the three-dimensional form of the vessel. To do this, as mentioned previously, only the three sections corresponding with the middle and the two extremities of the hull (called *corbe maìstre* or *da levare*) and the geometrical methods of reduction *schorere de sesto* are recorded.

Note that the authors of these and other manuscripts give great importance only to the *sagome* and *sesti*, and drew them with great precision while omitting the drawing of the ship as a whole: and if they did draw the ship, the drawing was so naive and lacking in detail that it was merely an *aide-mémoire*. The terminology is particularly interesting: every part of the ship, every tool, every phase of the construction process had – and still has – a specific name. Examples of the many still in use are: *cantier, cao, slànso, colómba, stéla maistre, córbe, piàne, bóca, pontàl, calcagnio, sumi, magèri, caéne* (these are just a few of the terms relating to the skeleton). To avoid misunderstandings and to accelerate the execution of the sections, even the most humble pieces of wood or other components, such as nails, had a specific name. All of these terms, which are not found in the usual marine vocabulary, were used not only by Venetian boatbuilders: through military and commercial cooperation they made up a real *lingua franca* spoken in many Mediterranean lands.

There are also similarities in the way the vessels were defined: alongside the technical name the boatbuilder wrote the name of the client. This demonstrates that they did not build standard models, but adapted the basic form – often with minimal changes – to match the requirements of the shipowner or captain. While Todaro de Nicolò writes: 'Rules Relating to the Construction of the Frigate made for Signor Gierolemo Contarini, a captain based in Cyprus', Bertotto writes much humbler annotations: '*Bragozzo* made for the *Magna Sionere* (the one who eats waterspouts) Launched on 8th January 1921', or 'My Godfather Toni's *Bragagna*'.

In conclusion, it can be said that the traditional Venetian construction methods are still valid for vessels of small and large tonnage, and that the methodology used, based on continual modifications dictated by experience gained from previous construction, is a method that is in its own way scientific. It can be compared with the way captains navigated without the use of dead reckoning or charts – not because they did not know how to use them, but because in a sea of limited dimensions, with shallow waters and labyrinths of tiny islands, it was safer to navigate by instinct than to rely on primitive compasses and charts.

The empirical techniques employed by traditional boatbuilders have a dignity which deserves to be recognised and understood. 'High' culture has always relegated this method of working to the fringes of knowledge in which legend, folklore and superstition are mixed together. But it should be remembered that the etymology of the word 'empirical' bears little relation to the negative meaning of 'hit and miss' with which it is now commonly used; an 'empirical' method is a method 'based on experience, on what can be proved by experiment'.

References

I would like to cite as sources not the usual publications, but teaching given me by others through their voices and gestures, as well as their boatbuilders' templates and memo booklets, at the same time begging forgiveness from those who have taught me, but whom I have inadvertently forgotten to mention here. This is not, then, strictly a bibliography, but is rather an "anthropography":

In Venice:

Angelo Marella, Nedis and Roberto Tramontin, Gastone Nardo, Giovanni Giuponi, Roberto dei Rossi, Gianfranco ("Crea") Vianello, Mario and Marco ("Botte") Vianello, Duilio Cavalier, Giampaolo Proto, Daniele Bonaldo, and Aristide Battistin. The shipyards Cucchin, Cucco, Casal, and Celli.

In Burano:

Antonio, Piero and Guido Amadi; Agostino Amadi; Vittorio Amadi, Nerio Molin, Rino Molin, and the Bovo brothers.

In Chioggia:

My family Bullo ("Niere"), beginning with my great-grandfather, *parón* Giovanni, his sons Lionello ("Nello"), Angelo, Luigi, and Giuseppe; Aristide and Gino Bertotto, the family Cimolin, Bullo Antonio and Carlo, Olindo Ranzato, the family Poli.

In Murano:

The family Astolfo; the shipyard "Pericle."

In Pellestrina and Portosecco:
Attilio and Giovanni Schiavon; Pompilio Menetto, Piero Menetto; the heirs of the ("Detto") Schiavon.
Outside the Venetian Lagoon:
Dino and Luigi Rondolini, of Pesaro, Italy.
Other valuable sources of information: Silvano Voltolina, Paolo Bonaldo, Sambo ("Nino") Violante.

52. Reconstruction of the *Hjortspring* Boat Sailing Tests

Knud Vagn Valbjørn, Niels Peter Fenger, Max Vinner

Preface

This paper succeeds two former papers by Valbjørn *et al.*, 2000 and Fenger *et al.*, 2000 both dealing with the reconstruction of the Hjortspring Boat. These papers report on the philosophy, the organisation, the building process, and the characteristics of the boat, as it was interpreted by Rosenberg and Johannessen (1937), such as the hydrostatics and hydrodynamics as well as the stress and strain picture. Subsequently the present paper and the above mentioned two papers should be considered a unity that describes the replica work and its results, although each paper may be read separately.

Further information can be found in the home page of Hjortspringbådens Laug: http://home6.inet.tele.dk/hjortspr

Introduction

In 1921/22 a boat was excavated in a little bog by the name Hjortspring. This bog lies in the middle of the island of Als, an island situated in the South of Denmark. Together with the boat was excavated a considerable amount of weaponry such as spears, swords, shields and mail coats together with various wooden artefacts. The find was interpreted as a sacrifice, and it was dated by the excavator to be from the Celtic (Preroman) Iron Age (Rosenberg, 1937). An excavation by Rieck in 1987 produced sufficient amount of "fresh" wood to perform a carbon 14 test. It was confirmed, that the find was from 350 BC (Rieck, 1994: 48).

The boat was 18 m long with a beam of two m. The shell of the boat was formed by five wide planks of lime wood, that were lashed or sewn to each other by some organic materials. In either end of the boat the two side planks and the two gunwale planks were sewn to a stem part, that was stepped onto the narrow elongation of the bottom plank.

Both ends carried horns like the horns that characterise the thousands of rock carvings in Norway, Sweden and Denmark.

The Replica Building (Organisation)

In 1991 a group of persons on the island of Als decided to spread the knowledge of the Hjortspring Find and as a major aim build and sail a replica in full scale of the boat. A legal organisation, Hjortspringbådens Laug (The Guild of the Hjortspring Boat), was founded in order to organise the work and to act as a platform for fund raising. The building of the boat started in the fall of 1993. Details are found in a previous paper (Valbjørn *et al.*, 2000). A total

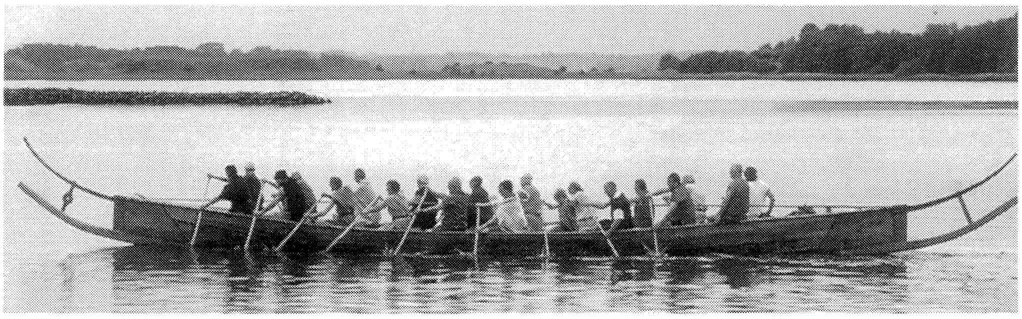

Fig. 52.1. The purpose of the guild: restoring the Hjortspring boat to life.

of 10.000 man-hours were logged for the boat building process.

May 29, 1999, early in the morning, the Hjortspring Boat kissed the waves once more after 2350 years of rest. The boat, named *Tilia Alsie*, is judges by the archaeological society in Denmark to represent the latest interpretation of the find, and its form, its finish and its elaborate details illustrate the advanced technology, that the boat builders of the North did command in the Celtic Iron Age.

The Boat

THE CONSTRUCTION

The Hjortspring Boat as documented by Rosenberg and Johannessen (1937) consist of five planks, two stems, four horns and ten frame systems, sewn together with strings of organic materials (probably lime wood bast). The five planks are each in one whole length. The lower horn (the keel horn) is assembled to the elongation of the bottom plank by means of a tongue and groove assembly as in the find. How the gunwale horn was fixed to the stem could not be established. We used a tongue/groove assembly there as well. The two locking plates in either end of the boat, connecting the two horns, were made of oak, fixed to the horns with oak keys.

The designs and functions of the plank steppings, the tightening mechanism and the frame systems will be dealt with in the chapter: "Hypotheses".

DIFFERENCES BETWEEN TILIA AND JOHANNESSEN'S DRAWING

The major difference between the replica and the interpreted boat as shown in Rosenberg (1937) is the sheer and the keel line of the bottom plank. At the root of the keel horn, the keel line is raised 24 cm in Johannessen's drawing compared to the keel line at the middle section of the boat, while the same distance in the replica is 36 cm. The gunwale at the middle section of the replica is 3 cm lower than that of Johannessen's drawing. The reason for this deviation is the curve required of the gunwale, before the gunwale plank is bent when mounting it. Johannessen's solution requires a 30 cm high curve, while the replica requires only 12 cm. The shape deviation explains the differences in stability and wave making resistance measured by the sailing tests compared to the predictions by Fenger *et al.* (2000)

Hypotheses

Many questions arose during the building of the boat. Some of them were answered through consultations with the National Museum, some we had to answer ourselves based on common sense and analogies with other parts of the boat. Finally some major questions and interpretation possibilities appeared that could not be confirmed right away, thus they must be treated as hypotheses.

These hypotheses have been studied during the tests of the boat.

TIGHTENING MECHANISM

The find indicates that the sewing seams were covered by an organic mass both inside and outside, interpreted as resin (Rosenberg, 1937: 82). The planks were overlapping.

After consultations with Rieck from the National Museum, we decided to deviate from this solution and make the plank stepping, the sewing and the stopping (Fig. 52.3).

During sailing there were several leakages at the sewing seams and at the string holes. They were stopped by means of ox tallow. Back on land we started smearing the seams with a mixture of spruce resin and ox tallow, 2:1. Should we continue to smear the seams with resin over the years, we will end up with an appearance of the seams like "the Rosenberg solution".

STEERING OAR MOUNTING

In the find were established two steering oars, one in each end. There was no indication, as to how the steering oars were mounted. Initially one oar was lashed with a short

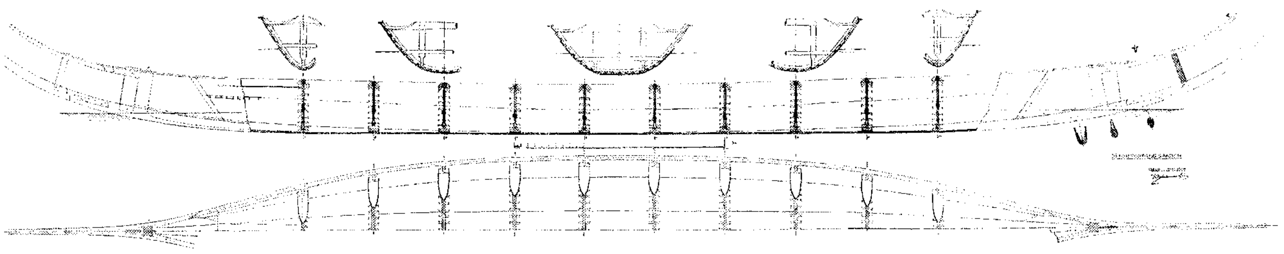

Fig. 52.2. The Hjortspring boat (Rosenberg, 1937).

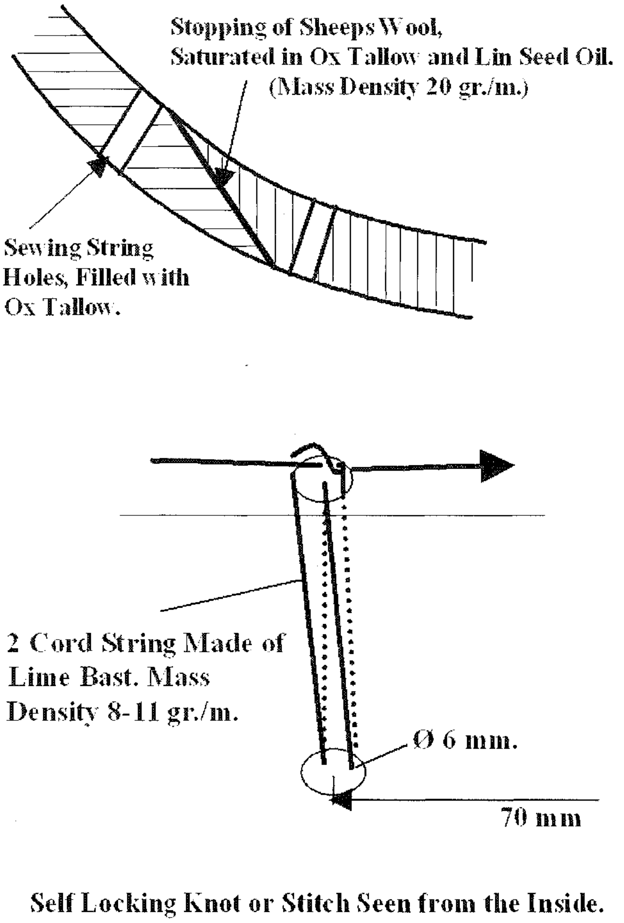
Stopping of Sheeps Wool,
Saturated in Ox Tallow and Lin Seed Oil.
(Mass Density 20 gr./m.)
Sewing String
Holes, Filled with
Ox Tallow.
2 Cord String Made of
Lime Bast. Mass
Density 8-11 gr./m.
Ø 6 mm.
70 mm
Self Locking Knot or Stitch Seen from the Inside.

Fig. 52.3. Plank stepping, stopping and sewing.

piece of string to the top of the most aft frame, where it protruded over the gunwale. The tests showed that this mounting gave a rather low directional stability. Obviously, this mounting was completely insufficient to steer the boat.

The first attempt of cure was to apply two steering oars aft, one on each side. This cure was partly a success, but it occupied the two rowing positions. With a strong quartering wind the boat was refractory as ever (Fig. 52.4).

In order to gain better control we extended the water line by taking 600 kg sand ballast onboard. With the mass of the crew of 1400 kg and the mass of the boat of 550 kg, it amounted to total displacement of 2550 kg. The result was a more stable boat as to initial stability, but the directional stability remained unsatisfactory.

The hypotheses of the above described steering oar mounting was consequently rejected. A practical solution to the steering problem was found as follows: the steering oar was lashed to the root of the lower horn, where this protruded out of the stern. Thus the steering oar could be turned around its own axis like the side rudder of a Viking ship. A cramp was fixed atwartships on the top end as a handle, and with only one helmsman right aft, sitting on the very top of the sternpost, this arrangement performed excellently (Fig. 52.5). From now on we had no difficulty making the boat go in the direction we wanted, and as an extra award, we got two more seats available for paddlers.

As mentioned above there were found one steering oar at the stem post as well. An additional steering oar was subsequently mounted, lashed to the forward keel horn on the port side. The effect was a further advance in

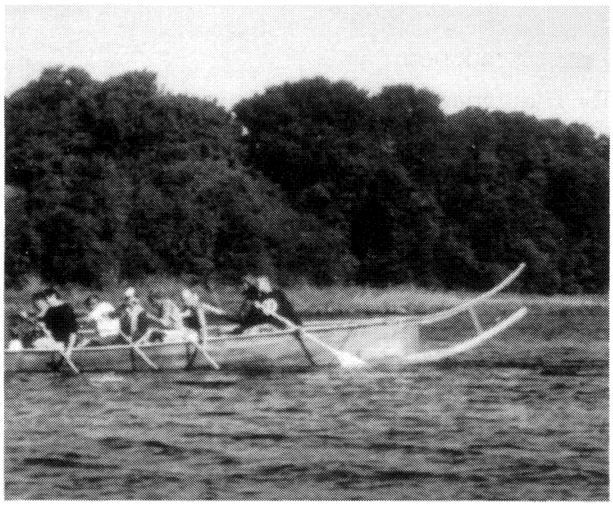

Fig. 52.4. First steering oar mounting.

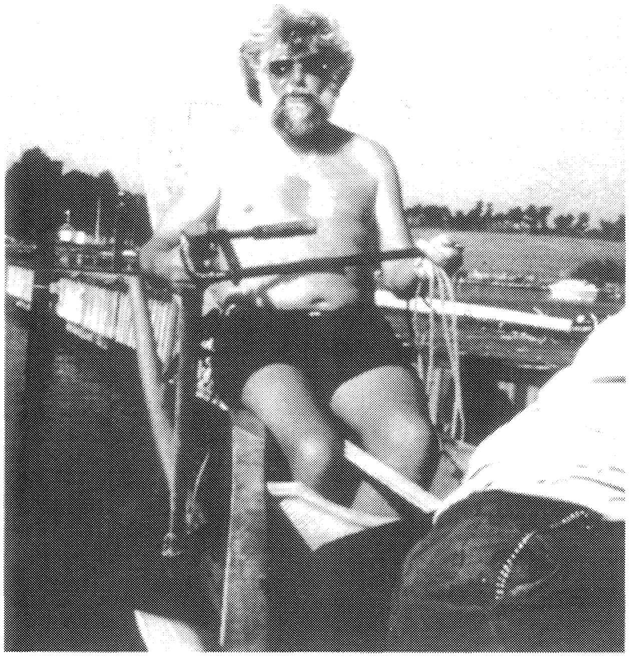

Fig. 52.5. New steering arrangement.

steering. With both oars the boat was under full control, sailing in the cove of Dyvig. A sailing through a narrow and meandering fairway leading to a neighbouring cove was performed steering with the forward rudder alone.

The boat was easily steered with either the aft rudder, the forward rudder or with both rudders in action. The original hypothesis was thus replaced by a new one.

Apart from further tests in the future, one must study the various solutions in African, Indian and Oceanic more recent canoes. Furthermore the original boat that is on display in the National Museum in Copenhagen must be scrutinised for traces of steering oar mounting.

STRESSES AND STRAINS IN THE BOAT

A major hypothesis was the application of a "trussing rope", connecting the set of four cleats on top of one stem to the correspondent set on the other stem using the cleats as a tackling block.

The original idea of suggesting a trussing rope stems from the existence of the stem cleats and a wish to explain their use. Furthermore initial calculations showed, that the boat shell was expected to be extremely flexible (Fig. 52.6).

Calculations (Fenger *et al.*, 2000) show, that when submitting the boat to a standard wave (length 13.5 m, height 0.65 m), the maximum stresses in the keel plank and in the gunwale were quite acceptable. The stems would, however, vibrate 30 mm in a vertical direction during hogging/sagging sailing, not considering the "pea-pod" effect. That this wave condition is not just a theoretical assumption is illustrated in Fig. 52.7.

The boat has been submitted to such high waves for thirty minutes only, as we were not convinced that the sewing seams could stand the shearing stresses over long periods of time (Fig. 52.7). Calculation shows that such stresses will exceed the elastic range of the lower sewing seam between frame 2 and 4 (and 7 and 9) leading to wear at the seams.

THE FRAME SYSTEMS

Each frame system consists of a frame, lashed to cleats that are integrated parts of the planks. This frame pierces through the thwart at both ends, through the deck beam

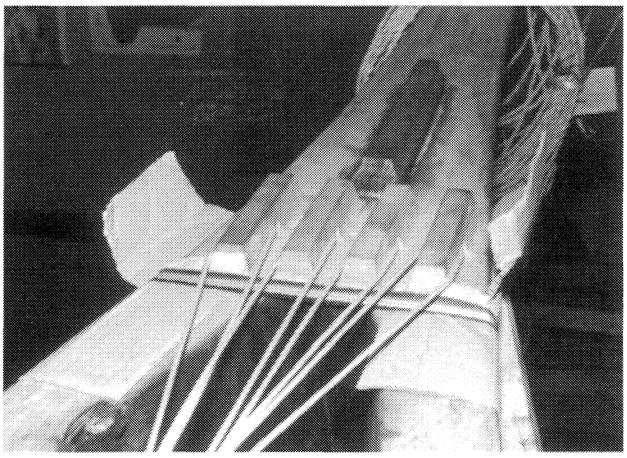

Fig. 52.6. Trussing rope block.

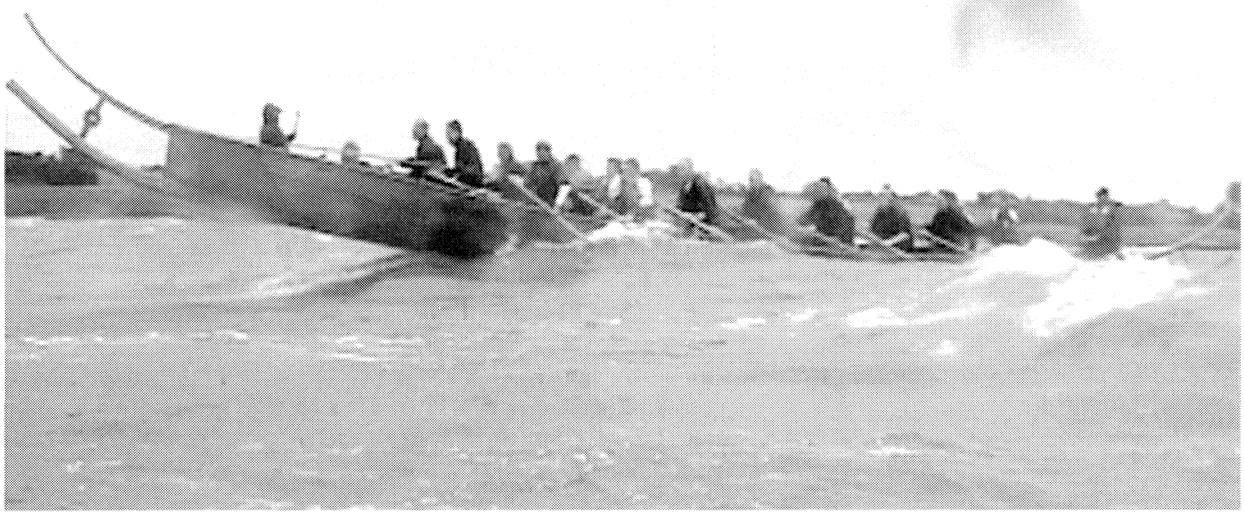

Fig. 52.7. Tilia Alsie in high seas.

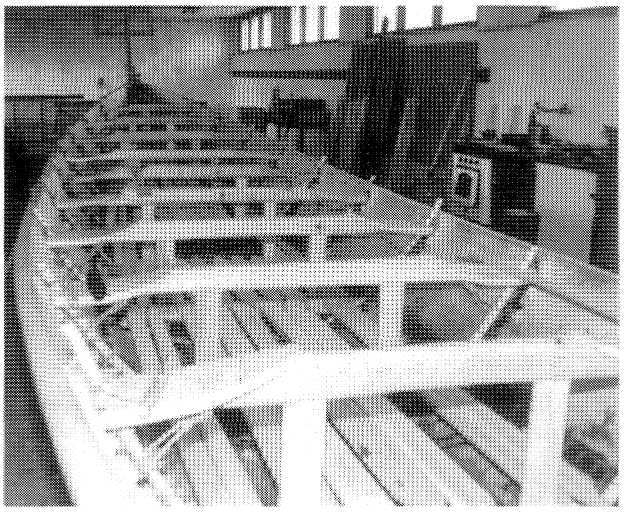

Fig. 52.8. The row of frame systems

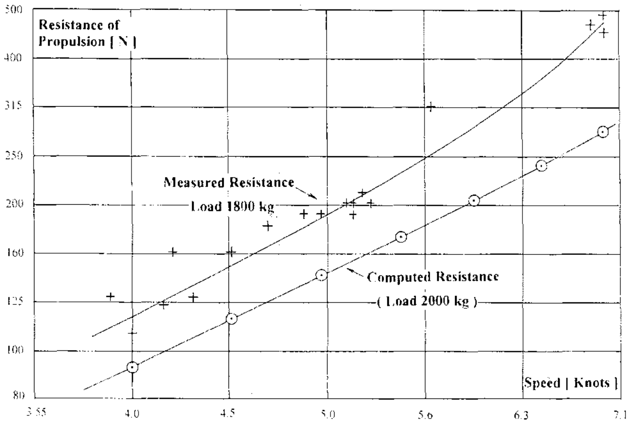

Fig. 52.9. Resistance of propulsion versus speed.

and through the lower end of the two columns (Fig. 52.8). More details are found in Valbjørn (1999)

Sailing Tests

INTRODUCTION

Apart from several sailings since the first launching in May 1999, Tilia has undergone two sessions of test sailings in corporation with the Centre for Maritime Archaeology and the Viking Ship Museum in Roskilde.

In 1999 the crew consisted of members of the Guild of the Hjortspring Boat together with students from the training centre of the Viking Ship Museum. None of these possessed sufficient knowledge and experience in paddling. The results from this first test run are considered as initials, but the tests gave indications of problems. It was, however, during the 1999 tests that the new hypotheses of the steering oar mounting was developed.

In the tests in year 2000 a picked crew of 22 very competent dragon boat paddlers, all former elite canoe and kayak athletes. Today they are united in a mutual effort of competing internationally in the Chinese Dragon boats, a design that is powered by 20 paddlers, a helmsman and a drummer. The crew had achieved several international rewards and medals, subsequently they were thought to represent the best possible replica of the original crew of the Hjortspring Boat 350 BC.

RESISTANCE MEASUREMENTS

The resistance of propulsion was measured by towing the replica after a motor sailer. The towing rope ended in a bridle, the ends of which were spread out by means of a boom fastened to the replica. The towing force was measured by means of a spring dynamometer placed at the towing vessel. The speed was measured by the GPS log of the towing vessel. The results are shown in a double logarithmic diagram (Fig 52.9).

The data show some scattering due to difficulties of keeping the conditions stable. They are compared to the total resistance computed (Fenger *et al.*, 2000, fig. 8). It is seen that the measurements are about 30 % higher than the computed values up to a speed of 5 knots.

Some factors were not taken into consideration in the calculations, and they could be the reason for this difference:

1. Rough bottom, especially the seams.
2. Air resistance.
3. Resistance of the rudder.

This could explain the difference.

STABILITY TESTS

The stability of the replica was measured by pulling upwards in the gunwale by means of a tackle as shown in Fig. 52.10. The force was measured by a spring dynamometer, and the tangent of the angle of heel was determined by means of a plumb line and a ruler as shown (Fig. 52.10). The measurements were made in three conditions (Fig. 52.11): the shape of the replica was measured by the Centre for Maritime Archaeology, Roskilde (pers. comm. F.Hocker), and from this the metacentre versus displacement and angle of heel was determined. The metacentre is somewhat higher than the values determined from Johannessen's drawings. The reason is the more pronounced sheer of the replica. This means that the righting moment is about 25% higher compared to the value found earlier (Fenger *et al.*, 2000).

During heeling the crew kept their position relative to the boat. In practice they will tend to counteract the heeling

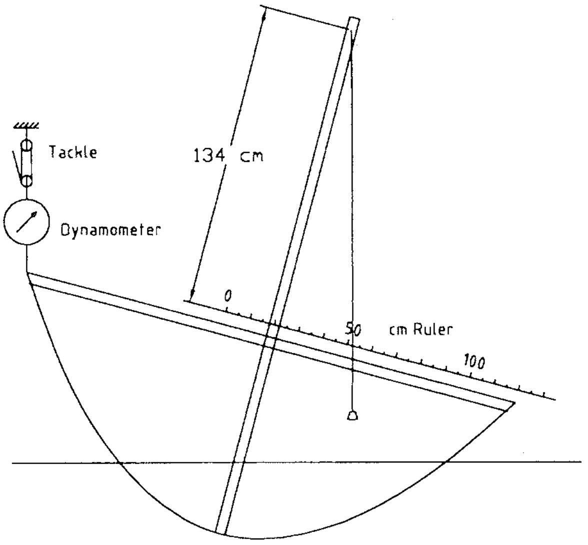

Fig. 52.10. Arrangement of the experiment.

by lean towards the heeling, thus giving a much higher stability.

From the measurements the centre of gravity of the empty boat has been calculated to be 0.47 m above the bottom of the keel plank. Also it is known that the mass of the boat is 530 kg. It is now possible to compute the righting moment for any load condition, if the mass and centre of gravity of the load relative to the boat is known.

MANOEUVRING TESTS

The Hjortspring Boat was a highly manoeuvrable war canoe. The boat could accelerate from zero to 6 knots within half a minute and a full brake stop from 5 knots to zero with all the paddles backing furiously in 5 seconds or half a boat length. A 180 degree turn (a U-turn) at 5 knot speed can be made in 37 seconds with a turning diameter estimated to be 30 m.

Turning 360 degrees on the spot with no velocity, letting one side of the paddlers row forward and the other side backing, was performed in 38 seconds. This manoeuvre was only possible in calm conditions, i.e. up to 9 knots wind velocity.

VELOCITY TESTS

The velocity tests took place over a measured distance, determined by a GPS-navigator. In 1999 the track was 1160 m. The untrained but spirited crew did its best and paddled all out, only to attain an average speed of 5.1 knots being the best of several tests. The condition was 9 knots wind from behind, a flying start and 47 strokes/minute with 16 paddlers being active. At 40 strokes/minute the speed was reduced to 4.3 knots. When only 8 paddlers worked, the speed was reduced to 3.6 knots, a mere reduction in speed of 16 %. Theory calls for a reduction of 21%, but by coincidence, it might have been the strongest 8, that were paddling in this test.

In 2000 the track was 1148 m. In the first run, the dragon boat crew reached an average speed of 7.6 knots. The conditions were a faint wind from behind, a flying start and 62 strokes/minutes. During the run the GPS-navigator was fluctuating between 7.4–8.2 knots.

It was established, however, that 8 knots were reached, a magic number, that have been discussed heatedly in the Guild during the building period of *Tilia* as an attainable maximum speed.

Further test trials gave no improvements in speed. As the crew was accustomed to much shorter periods of sprinting, the track was halved. This measure did not, however, result in better average nor top speed.

With regard to long distance paddling, the dragon boat crew estimated that a cadence of 55 strokes/minute could be maintained all day long (for 10–12 hours). This cadence was tried several times and gave a steady velocity of 6 knots in calm conditions, i.e. with moderate wind and wave resistance. Even with short stops for eating and relaxing, (or letting half of crew rest at a time), this average speed would result in a day distance of 50–60 nautical miles. This hypothesis will be investigated in 2001.

Heavy sea sailing

The last day of the tests in year 2000 there was an opportunity to test the boat in a strong wind, gusting up to 30 knots with corresponding heavy sea outside the cove of Dyvig. 18 paddlers took part in this test, as the two foremost did not have sufficiently long paddles and their foot rest was inadequate. The cadence was kept at 55 strokes/minute.

Inside the sheltered cove of Dyvig this gave an expected velocity of 6 knots, but outside the speed through the

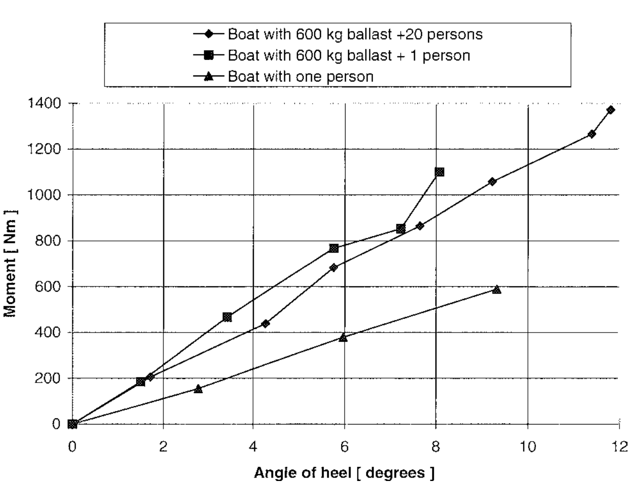

Fig. 52.11. Righting moment versus angle of heel.

water decreased gradually as the seaway increased. Simultaneously the leeway rose accordingly.

With the waves hitting the boat at 45 degrees on starboard, the speed was reduced to 4.8 knots and the leeway went up to 12 degrees (in 20 cm waves and 25 knots of wind). With 28 knots of wind and 75 cm high waves the corresponding figures were 3.5 knots and 14 degrees of leeway.

Outside the lee of land the course was directly against the wind that had increased to 36 knots. The waves were now one meter with occasional breakers. The boat was still comparatively dry, apart from some water leaking through some of the seams. Occasionally a wrong sea hit the boat. This was not dangerous but reduced the speed to 2 knots.

During the wave sailing it was paramount to keep the paddle vertical during the stroke and maintain a firm grip with the lower hand near the top of the blade. During the entrance of the cove the waves decreased but the strong wind being on the beam caused a leeway estimated to be 15–20 degrees.

The Paddling Process

THE PADDLES

The paddles of the find were all different indicating that each crewmember had his own individual paddle. For the replica it was decided to make a set of 20 identical paddles with a total length of 1.52 m and a blade length of about 0.5 m. During the tests it was observed that the paddlers at the two front and the two most aft thwarts had difficulties reaching the water with their paddles. The reason for this is the sheer of the boat, which is more pronounced compared to Johannessen's drawings. This shows that there are good reasons for paddlers to have their own individual paddle.

The dragon boat team tested their own paddles with the replica. These paddles are wider than the Hjortspring paddles. The comparison gave rise to many comments. Other comments came from Haupt (internal report from the Centre for Maritime Archaeology at the National Museum of Denmark, 2000).

KINEMATICS OF PADDLING

The paddling process was recorded by means of a video camera from a following boat. A single paddler with his paddle was studied. In order to record horizontal coordinates the gunwale of the replica was marked with red tape for every 10 cm over a distance of one metre in front of and one metre behind the paddler. His paddle was also marked with red tape for each 10 cm. The time was recorded by means of a special clock with a pointer rotating two revolutions per second. This clock was raised on a pole in order to keep it visible. Fig. 52.12 shows the arrangement of the experiment.

From the video records one single paddle stroke was selected for further analysis. A series of exposures from this stroke was printed on paper. The position of the paddle versus time could then be measured. The results are shown in Fig. 52.13

The best paddling technique was to keep the paddle as vertical as possible, when it was in the water. The diagram shows that the blade of the paddle is almost vertical, when it is set into the water and remains so for some time. This ideal position can unfortunately not be kept. Before the paddle is withdrawn from the water it makes an angle of about 45 degrees to the vertical direction, and this part of the stroke is therefore less efficient. The effective length of the stroke is estimated to be one metre as indicated in the figure, and time required for this is about 1/4 of the time of a full stroke.

Three closed curves are shown in Fig. 52.13. The upper one is the trajectory of the top of the handle of the paddle where the inner hand of the paddler is placed. The lower one is the trajectory of the blade tip, and the middle curve is the outer hand of the paddler placed approximately at the middle of the paddle. This position is rather close to the centre of gravity of the paddle, subsequently giving information about the work required for lifting the paddle against gravity in each stroke.

Theoretical considerations

A theoretical model of paddling has been developed. A paddle can only apply a propulsive force, when it is moved backwards relative to the surrounding water. Each stroke is assumed to consist of a working stroke, where a constant force is applied. After the power stroke the paddle is immediately lifted up and moved forwards with a constant velocity. This is called the return stroke. After this stroke the paddle is instantly plunged into the water at boat

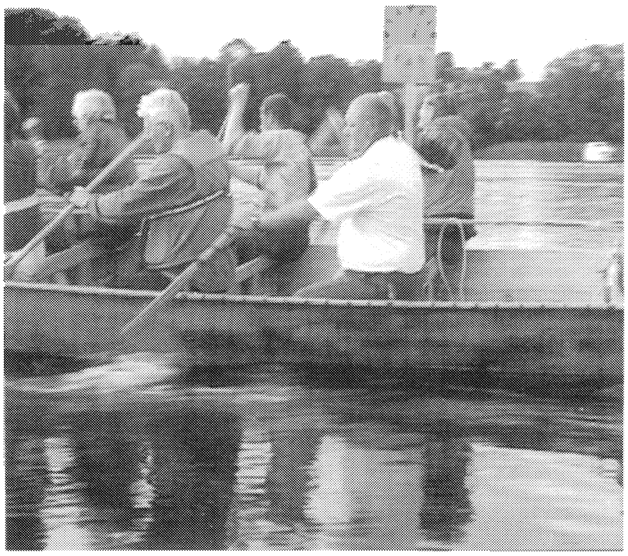

Fig. 52.12. Paddling experiment.

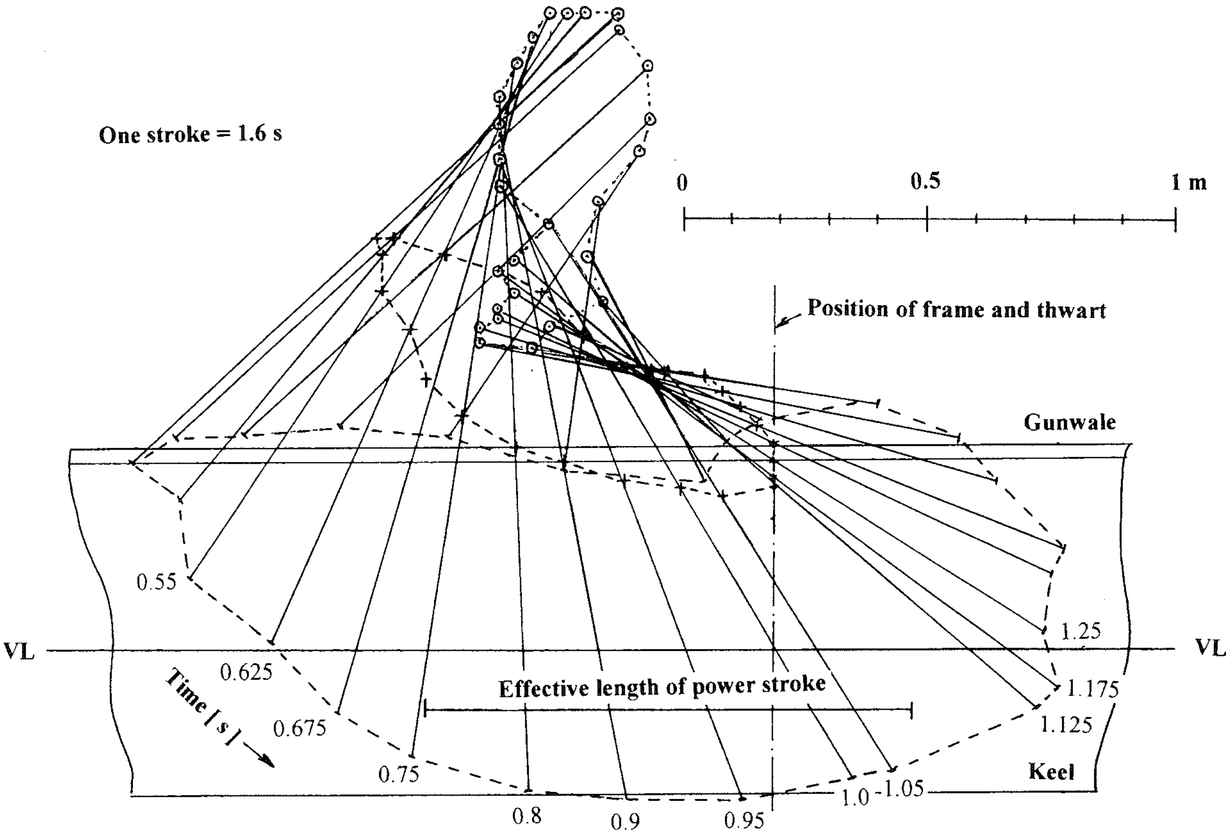

Fig. 52.13. Position of paddle during a full stroke.

velocity, and a new power stroke commences. A simplified kinematic model has been developed based on this concept. Details about this model is found in Hjortspringbådens Laug, Medlemsmappen, section 2.5.2 (1991).

Efficiency of paddling

The propulsion force for moving the boat with a given velocity is determined by measurements, see Fig. 52.13. In Fig. 52.13 it is seen that the effective length of the power stroke is 1 m and this stroke is 25 % of the time for a full stroke. Using these observations in the theoretical model it is possible to calculate the hydraulic efficiency of the paddling process and the paddling frequency versus boat speed (Fig. 52.14).

The two single points are measured mean values from tests in 2000.

It is seen that the paddling frequency varies almost linearly with boat speed. During tests in 1999 it was found that the number of strokes per minute is approximately 10 times the speed in knots, when there was not too much head wind. This shows that the rather crude theoretical model is in a reasonable accordance with the physical reality.

With the input data the model gives a hydraulic efficiency about 0.75, decreasing slightly with boat speed, as seen in Fig. 52.15.

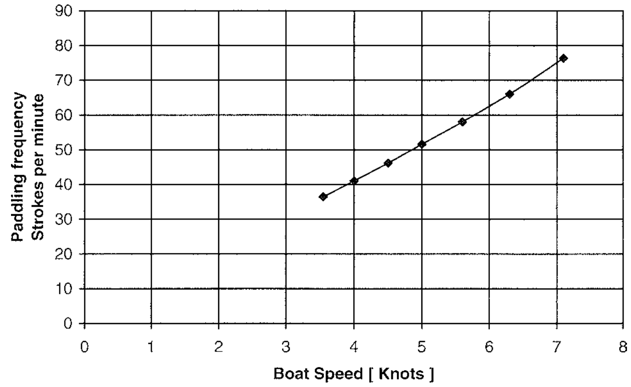

Fig. 52.14. Paddling frequency versus boat speed.

The hydraulic efficiency gives information about losses due to eddies around the paddles (Fig. 52.15). But there are other losses, which should be taken into consideration. Each time a paddle is taken up from the water a work is done against gravity. This work is not regained, when the paddle is lowered and is consequently lost. This could be expressed as a mechanical efficiency. The mass of each paddle is approximately 1 kg, and from Fig. 52.2 it is seen that the paddle is lifted roughly 0.5 m. This gives a

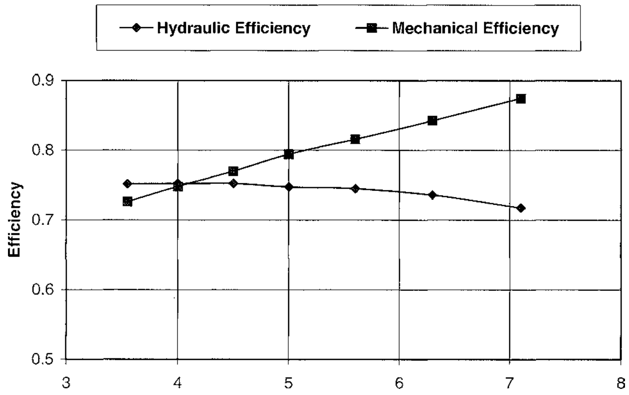

Fig. 52.15. Hydraulic and mechanical efficiency versus boat speed.

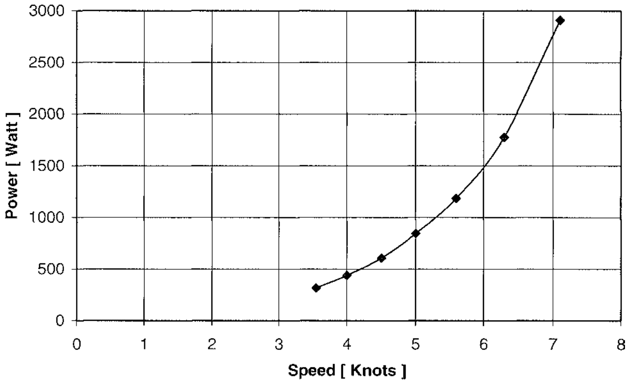

Fig. 52.16. "Shaft horse power" versus speed.

mechanical efficiency, which is roughly 0.8, increasing slightly with boat speed. It should be kept in mind that besides the work done against gravity, the paddles are also accelerated and decelerated during a stroke. This requires some work as well, and it is not regained and gives rise to extra mechanical losses. They are not taken into account at the time being.

The resistance of propulsion is shown in Fig. 52.13. Multiplied by the boat speed, we get the effective power for propulsion. Dividing this by the two efficiencies from Fig. 52.15, we get the power, which is equivalent to shaft horsepower of an engine driven ship.

This power is shown in the Fig. 52.16.

The width of the paddles

A question much discussed is the optimum width of the paddles. For an analysis of this question a theoretical model is useful, especially, if it has been verified. Intuitively it is felt that paddles with a large area will have a better grip in the water and therefore a higher hydrodynamic efficiency. This is confirmed by the model.

But as wood was the only material available for paddles, and wider paddles will have a higher mass, there is a limitation deriving from the strength of the paddlers. Using the theoretical model it has been examined, what the consequences would be, if the width of the paddles are doubled, and their mass is increased by 50 %. It has been shown that the two tendencies more or less counteract each other. Also it is obvious, that broad paddles are more vulnerable to damage.

Conclusions

It was the intention that the present paper should conclude the reporting of the reconstruction of the Hjortspring Boat and the testing of the replica.

Although many questions have been answered, the work of the testing has, however, produced new ones. A whole list of such additional testing is already present.

But let us stay with the present findings:

- the construction of the Hjortspring Boat, as it is represented by *Tilia*, is flexible and sturdy;
- the stresses of the sewing seams have not resulted in bursting of the strings;
- the tightening of the sewing seams is adequate but not completely convincing;
- the deck boards support the feet of the paddlers fairly well, but strength wise they are on the low side;
- the hypothesis of the trussing rope remains a hypothesis;
- a steering oar mounting was developed. The function was excellent, but it still remains a hypothesis;
- the paddles should have different lengths according to their position in the boat;
- the width of the paddle blades as used (9 cm) is evaluated as being well chosen for longer periods of paddling;
- the paddles should be as light as the necessary strength permits;

The following statement describes the functional value of the Hjortspring Boat:

- the boat is very manoeuvrable with regards to accelerating, braking and turning;
- the boat is unstable when boarding, but when sailing it was felt stable and secure;
- the Hjortspring Boat, as represented by *Tilia*, is a fast boat. Sprinting velocity can reach 8 knots;
- it is expected that the boat may have a day range of at least 50 nautical miles;
- the boat can negotiate waves up to 1 metre, shortly at least;
- the boat is easy to launch by carrying it out into the water, and it is suitable for landing on a beach;
- a paying load of 0.5 tons, excluding the mass of the crew, is quite acceptable.

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53. Slavonic Boat Reconstructions in the Open Air Museum Gross Raden

Trixi Gülland

Historical background

On a peninsula in lake Gross Raden the Slavs settled in the 9th and 10th century. After its excavation the settlement was partly reconstructed and opened as the Archaeological Open Air Museum in Gross Raden (Mecklenburg, North-eastern Germany). Beside the huts it features a temple, a ring-fort and a bridge. In 1997, ten years after the museum's opening, a project started to build a reconstruction of an early medieval Slavonic boat. The chosen vessel was wreck No 2 from Ralswiek.

Ralswiek 2 is one of four boat finds from the Slavonic trading station Ralswiek on the island of Rügen – Western Pomerania (Herfert, 1968; 1973; Herrmann, 1980). The wreck was discovered in 1967 and kept in situ until it was recovered in 1993. This clinker-built boat of oak was exceptionally well preserved. The excavator believes it had been deliberately dug in to be hidden from enemies, but broke when lowered into the pit and was left in the ground (pers. inf. by P. Herfert). Dendrochronology delivered a felling date for the timber of shortly after 977 AD and a provenance from either Eastern Mecklenburg or Northern Poland,[1] both Slavonic areas at the time. Beside keel, several frames and knees the port side was found with all seven plank strakes whereas on starboard only three were still in place. That was due to the sloping hull position. Only a part of the stem could be found, the stern post was missing as well as the adjacent plank parts. Nevertheless, the amount of material was sufficient and the Landesamt für Bodendenkmalpflege Mecklenburg-Vorpommern[2] (State Organisation for the Management of the Archaeological Heritage) decided to build a full-size reconstruction in Gross Raden.

Reconstruction

The boat timbers underwent the common procedure for a reconstruction: full scale drawing, producing in cardboard and wood in scale 1:5, assembling to a model and thereby reconstructing the boat's shape. On port side the plank strakes were completed and a fifth oarhole inserted in the aftship. Stem and stern had to be designed on the base of the stem part, its rabbet and the adjacent plank strake scarfs. They indicated that the plank lines were running up on the stem and would not meet it straight. Therefore stem and stern post were reconstructed as being of round shape with stepped plank ends.[3] For technical reasons the first and second strakes ended in butts. During reconstruction the port side was mirrored onto starboard, although the remaining strakes on starboard were built asymmetric. Symmetric reconstructions are the common practice, but it can be discussed whether an asymmetric one is more realistic and achievable. Consideration must be given to factors such as a longer duration and more imagination for the reconstruction and the assumed purpose or cause of the asymmetry. According to the reconstruction this boat is 9.05 m long, 2.55 m wide, has a height amidships of 0.76 m and a draught of 0.45 m (Fig. 53.1).

Building process

In March 1997, the keel was laid down for a reconstruction of *Ralswiek 2*.[4] As far as possible the authentic materials, tools and techniques should be applied. Use was made of modern tools when they had no effect on the final result. The timber was used fresh or stored in water. Oak trunks of 0.9 m in diameter were radially split and trimmed with the broad axe to planks of 1.4 – 1.7 cm thickness. Stem and stern were chopped from crooked oak wood and fastened to the T-profiled keel by iron nails. Starting from the stern the plank strakes were built up. The planks are fastened to each other by treenails, secured with oak wedges. For bending the planks were heated on an open fire. As on the original only little iron was used: a few nails and rivets on keel, stem, stern and scarfs. Where the caulking material – wool, dog and human hair – lies in a groove between the planks a decorative moulding is

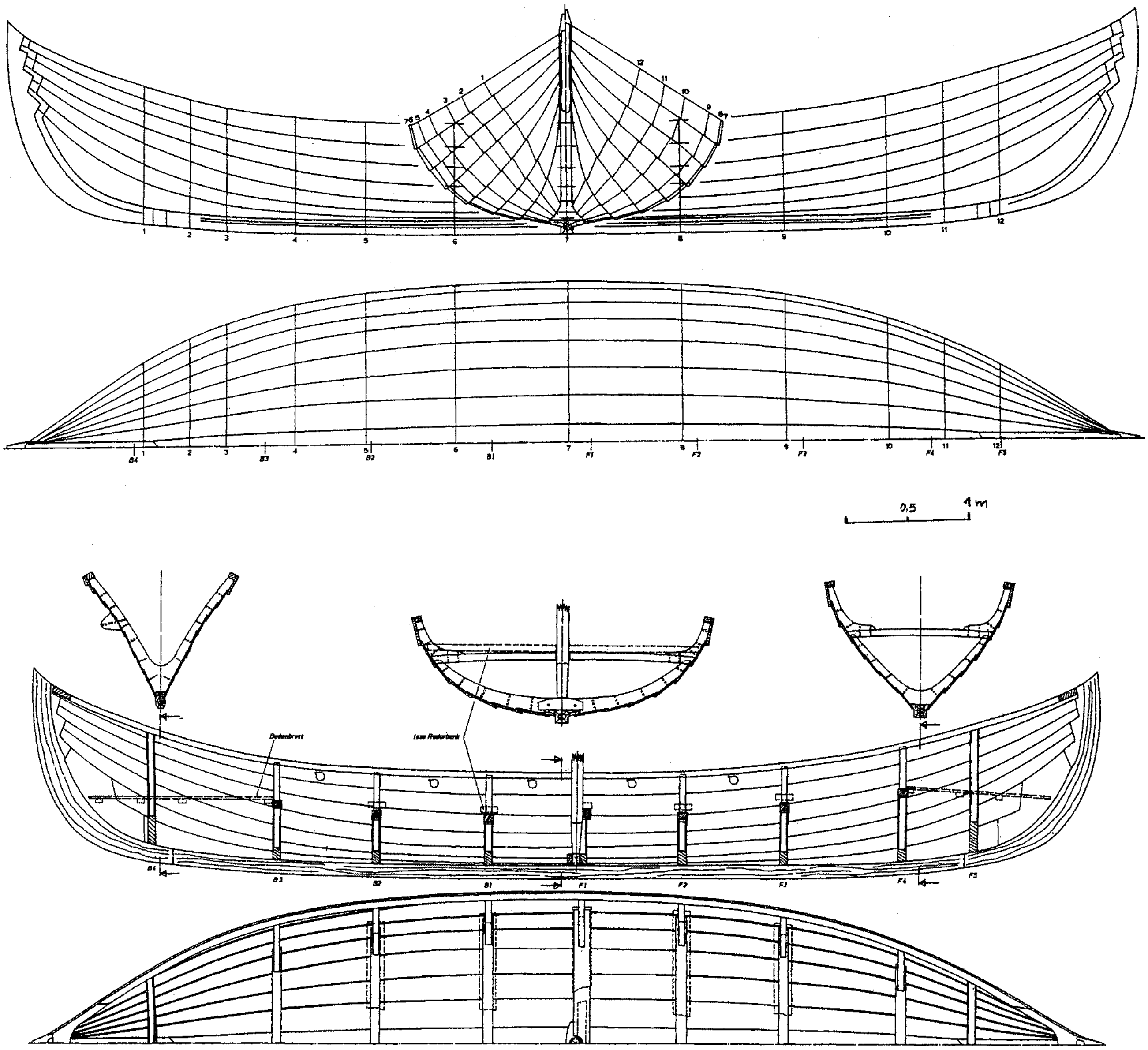

Fig. 53.1 Sheer plan and body plan of Ralswiek 2; *longitudinal section, cross sections and top view of the reconstruction. (drawing: J. v. Fircks, H. Jensen, Archäologisches Landesmuseum Mecklenburg-Vorpommern).*

carved on the planks' outside. It also decorated the side of the original stem, but this was first discovered when the replica was finished. With completion of the 5th plank strake the insertion of the frames started. Cross beams and knees followed after the sheer strake was fixed. This strake is 2 cm thick and inboard reinforced by a pinewood stringer. Five oarholes were cut into each side. Their width determined the size of the oar blades. These and the oarhole-locks were designed after finds from Hedeby (Crumlin-Pedersen, 1997).[5] For the rudder a find from Southwold was copied in smaller scale. The existence of a sail was verified by the original mast step on the main frame and two holes in the sheer strake abeam the mast, which were interpreted as fastening points for a shroud. Since nothing remained of the rig it was reconstructed with a square sail of 22 m^2.[6] For better support an aft stay and an additional aft shroud pair was placed on the boat. The standing rigging is fastened with shroud-pins alike a Fribrødre-Å find. A continuous rope was chosen for both the sheets and the braces. The position for the tack pin hole was gained by test sailing.[7] In a dry state the finished hull weighed only 650 kg, the rig another 80 kg. A stone ballast of over 500 kg was taken on board.

Two replicas

The first boat reconstruction *Bialy Kon*[8] was launched in

June 1998 and later joined by a second replica *Dziki Kon*[9] in April 2000. They differ in a few features (see Table 53.1).

Trial voyage

In August 1998 a trial voyage[13] was undertaken with *Bialy Kon* through sheltered waters from Ralswiek to Wolin. Three out of the five crew-members were rather inexperienced in sailing, so the crew could attend a specially organised square sail course in Roskilde beforehand. This voyage was to serve two objectives (Englert *et al.*, 1998b). On one hand it should be travelled under as realistic as possible medieval conditions and without modern navigational aids except sea charts. On the other hand standardised rowing and sailing tests were to be carried out. These should deliver electronically recorded data concerning speed, manoeuvrability, seaworthiness, windward performance, stability, cargo capacity, etc. After this project it was concluded that a trial voyage should not be combined with regular tests, because one rarely gets the right test conditions on the way towards a destination. Nevertheless, a trial voyage can be a separate method to deliver an insight for instance to the necessary times and conditions for water transport. This data can then be compared to historical sources.

During the voyage *Bialy Kon* proved to be seaworthy, dry, safe and bearably sailing. The boat could sail in different weather conditions and reach every chosen camp spot (Fig. 53.2). The small crew was able to handle the vessel under oars and sail. *Bialy Kon* travelled a distance of 135 nm, of which 25 nm were rowed in 17h and 110 nm were sailed in 27.5 h. Including the breaks at sea this gives an average travel speed of not more than 2.37 kn. The maximum speed recorded was 8.9 kn through the water when sailing with two reefs in broad reach and a wind speed of 13 m/s. The boat could be rowed with the mast laid against moderate to strong winds and low currents. Laying the mast is a matter of a few minutes only and decreases the wind resistance substantially. Against moderate wind it could be rowed with 1.43 kn but including breaks the travel speed amounted only to 0.93 kn. During a rowing test in 4.2 m/s wind speed 3 kn were scored with and 2.14 kn against the wind (each time four rowers). The Southwold rudder did not correspond well with the hull, the lateral area had to be enlarged on tour. Several oars broke and a few were mended.

Further experiences in sailing and boat handling

In the following years a boat group was set up, i.e. a group of people with a keen interest in handling and maintaining these replicas. When sailing on the lakes adjacent to the museum difficulties were experienced with tacking. Often an oar was needed to go round. The problems were as follows:

- the boat was not properly trimmed;
- the crew was still training itself;
- these lakes are a different sailing area;
- a new asymmetric rudder (after the large Fjørtoft boat) was not finished in detail and finally a longer rudder boss had to be fixed.

After the 2nd boat was launched in 2000 it made a substantial difference to sail together and compare the boats' performances. The trim was improved and the crews better trained, so *Bialy Kon* was tacking well. But *Dziki Kon* could neither tack well nor sail much windward. There was still a trim problem in the beginning. More seriously did the new woollen sail cause difficulties (Fig. 53.3). The

	Bialy Kon	**Dziki Kon**
Stem and stern post	winged, i.e. hollow on the inside	– solid rectangular cross-section, therefore a little sharper (planks meet them at a smaller angle) – taller stem and stern – plank lines continue as carving to the top
plank lines on entire hull		less regular (one reason is probably the lower-quality timber available)
frames	mistake made: second frame before the mast (foremost rowing bench) inserted *circa* 5 cm too close to frame behind	frame put on right place thus making rowing easier
short hood-ends	on all plank strakes	not on the sheer strake, planks of regular length fastened to stem and stern since their meeting angle is very small
knees	not fastened to sheer strake since no hole found in the original	a few knees fastened by large treenails (where gaps to the shell occured in *Bialy Kon*)
rig, usually	linen sail and hemp ropes[10]	woollen sail (woven and sewn by hand[11]), ropes[12] of hemp, limebast and horsehair

Table 53.1.

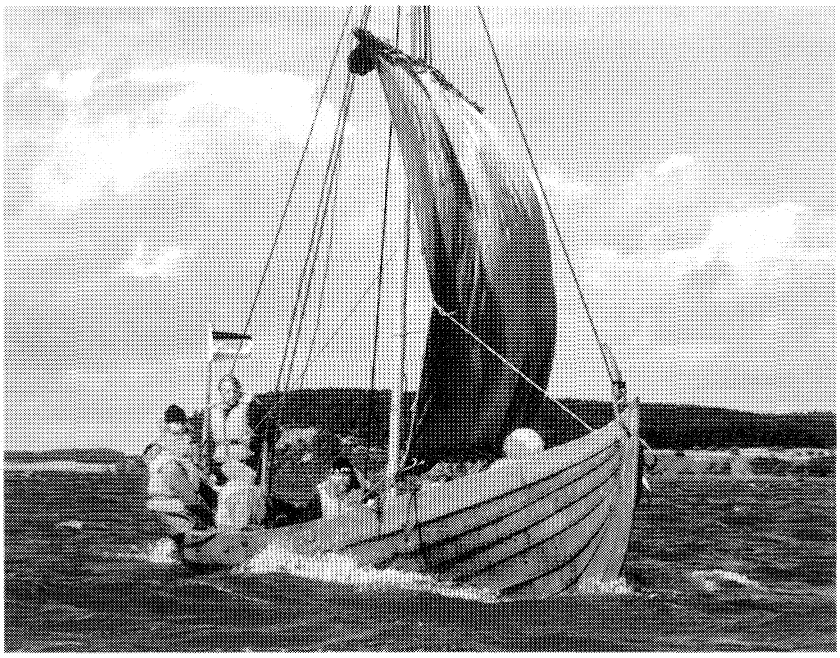

Fig. 53.2 Sailing double-reefed on the Oderhaff (photo: D. Gregory).

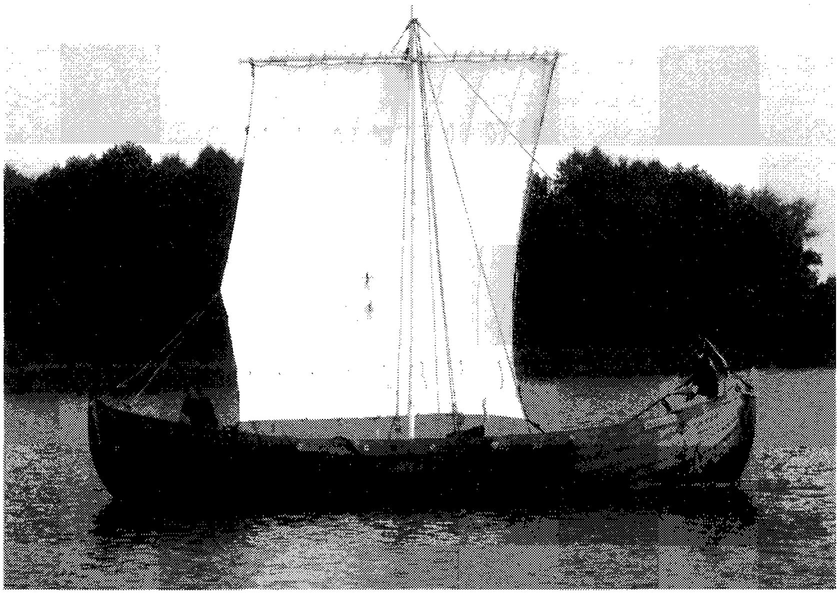

Fig. 53.3 Initial sailing with Dziki Kon's *woollen sail (photo: author).*

fabric was more or less permeable for the wind. It had to be sailed 'raw' for two days and was afterwards greased with beef tallow to make it windproof and smooth. Eventually another problem occurred – the sail had changed its size. One side had become longer than the other one. The sail could not be stretched between the yard and tack pin anymore. There also appeared a lot of folds in the fabric and the sail had become somewhat baggy. That is a definite disadvantage when sailing in beam reach or close-hauled. The sail will have to be examined again and adequately treated (possibly shortened) in 2001.

In 2000 *Bialy Kon* sailed a short trip along the Kattegat coast and into Roskilde Fjord. Later it crossed the open Baltic from Falster (Denmark) to Mecklenburg (Germany). This trip confirmed the previous experiences: *Bialy Kon* again sailed dry and safe, the latter distance of 25 nm in 5 h with a wind of 5–6 Beaufort in beam and broad reach. This time a maximum speed over ground of 6.6 kn was recorded. As on the 1998 voyage the boat was capable of sailing in strong winds and short, steep waves which makes it ideal for the Baltic Sea.

Some habits in handling these boats developed during the different activities. Already on the trial voyage it became a routine to loosen the leeward shroud abeam the mast when sailing close-hauled to give the sail a better shape (Englert *et al.,* 1998b). When sailing in broad reach the position of the tack pin can be moved aft by using the first oarhole. The communication between rowers and helmsman still has to be improved so that the rudder can be lifted immediately when the oars touch the ground.

One of the boats' peculiarities concerns rowing. The spaces for the 5 pairs of rowers are so narrow that they often obstruct each other. If the people are seated alternately close to the centre line and to the boat's side it works a little better, but the impact of the rowing may then be fairly little. Of course, the people 1000 years ago were smaller than we are today. Interestingly, the problem rather lies in the little distance between one oarhole and the next bench. Even small people tend to hit the back of the person rowing aft to them. So far a solution was found by rowing with six people only. Thereby only every second bench is used. Handling the oars is generally not an easy task on these boats. It happens frequently that the oars get stuck in the water and the oarholes when the vessel is in motion. If the oars cannot be lifted from the water they may break the oarholes. In this situation the position of the oarholes in relation to the thwarts (of which there was no evidence) seems inconvenient since the oar's handle is already on one's legs and cannot be pushed further down. One oarhole broke off on *Bialy Kon* (it was sitting close to a scarf, Fig. 53.4) and a stretch in the portside sheer strake had to be renewed in 2000. It could be worth trying oars of strong ash wood[14] since they can be slimmer and thereby of a smaller risk to the holes. The oar-turning technique as in cutter rowing was tried too. After one stroke one would turn the blade quickly that it floats up itself and one is only leaning on the thwarts. However, this needs some level of practice and is quite strenuous in the arms if not done right, but it should be further trained.

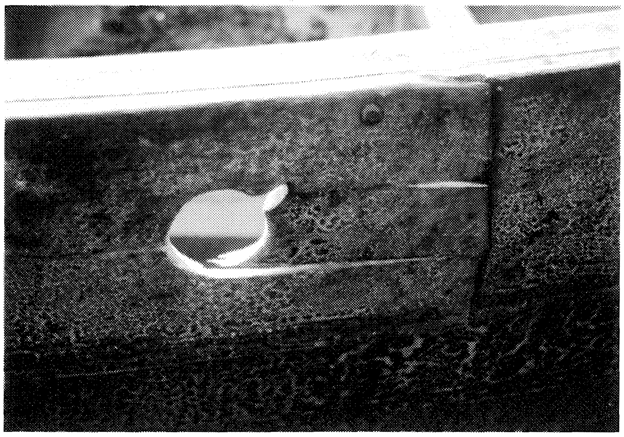

Fig. 53.4 Broken oarhole (photo: author).

The boats are monitored concerning their physical state. Several oars of the first set broke due to low-quality pinewood. Also the new ones break now and then. This might be a general characteristic of the local pine, which grows rather fast and is therefore not very flexible. The treenails are at some spots pulled into the planks despite their heads and a gap occurs. On the sheer strake stringer this can be observed too. This suggests that willow might be too soft for this purpose. The original treenails were made of buckthorn and willow. But only willow was available for the replicas. The leaking of the hulls is usually as little that bailing once a day is sufficient while being on tour. Sometimes leaks occur after trailer transport, preferably on scarfs. They can usually be mended easily. The change of fresh and salt water helps to put a limit on the vegetation and animals on the underwatership.

Conclusions

Bialy Kon and *Dziki* Kon are the first true Slavonic boat reconstructions. There is hardly any practical experience with this type of vessel (Westphal, 1996; Filipowiak, 1997). For the museum and the boat group it is a great challenge to sail and test these boats. *Ralswiek 2* was probably a small cargo vessel for coastal and large inshore waters, to be rowed and sailed on different beams. A possible windward angle of 60–65° seems realistic. It increases by the number of reefs. Generally speaking, because of its round hull and the flat keel this boat is more likely to drift than comparable Viking boats. When sailing close-hauled and tacking steering mistakes are crucial. Especially since the boats tend to sail considerably backwards while tacking. The boats are quite sensitive to the trim. Sometimes tacking would not work without moving living ballast. The stone ballast should be at least 400 kg; 700 kg were also successfully tested. Again, improving the performance depends on the right place for a heavier ballast. Future test objectives are for example:

- effectiveness of tacking compared to rowing on a longer stretch;
- relation of the cargo weight to the sailing performance;
- best trim – also considering differences for different wind directions;
- speed potential for a trained rowing crew;
- optimum time at sea for long-distance travels.

Apart from the scientific aspect the boats shall be made available to the public. If not in use they are moored up beside the ring-fort. The museum hosts special activities throughout the season when rowing tours are offered to the visitors. Upon special interest it is possible to make a few-hours tour with rowing and light sailing and special trips in 'safe' sailing areas for several days respectively. In order to include the locals in the boat activities a crew of high school students is trained in rowing and sailing. Outside the museum regattas with some traditional background, square sail events and other events relevant to the museum are on the schedule. These serve to present the boats to the maritime world, promote the museum and raise the awareness of a Slavonic maritime culture 1000 years ago. This is a field to catch up a lot since the majority still associates medieval clinker boats with the Vikings only.

Acknowledgements

This project would not have been possible without the support from the Centre for Maritime Archaeology and the Vikingshipmuseum in Roskilde (Denmark) regarding reconstruction, building, delivery of the rig and trials. Special thanks should be expressed to Ole Crumlin-Pedersen and Erik Andersen.

Notes

[1] Dendrochronolgy report by K.U.Heußner, Deutsches Archäologisches Institut Berlin.

[2] In person Dr. Friedrich Lüth.

[3] This feature can also be observed on the wreck *Orunia 1* (Lienau, 1934).

[4] The project was led by the experienced Faroese boatbuilder H. Jensen who could later train the German boatbuilder K. Zausch in the necessary skills.

[5] In Englert *et al.*, 1998b the oarhole-locks were by mistake assigned to a find from Fribrødre Å (Denmark).

[6] By E. Andersen, Viking Ship Museum Roskilde, based on his research on traditional Nordic square sails and Viking vessels.

[7] Executed by E. Andersen.

[8] Polish for White Horse

[9] Polish for Wild Horse

[10] Delivered by ropemaker O. Magnus, Hornslet (Denmark).

[11] Carried out by master weaver S. Schwarz, Gross Raden and sailmaker N. Hansen, Copenhagen.

[12] see note 10.

[13] Initiated by G. Indruszewski and A. Englert from the Centre for Maritime Archaeology Roskilde.

[14] An advice given by D. Goodburn.

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